EARLY MISSISSIPPIAN BLASTOIDS FROM WESTERN MONTANA

JAMES SPRINKLE[1] AND RAYMOND C. GUTSCHICK[2]

ABSTRACT. Several faunas of Early Mississippian blastoids occur in the Lodgepole and Allan Mountain Limestones of western Montana. More than 1,400 complete specimens representing at least nine genera and 16 species have been collected from three different zones, making this one of the largest blastoid collections known from western North America. The largest and most diverse blastoid fauna occurs just above the base of the Lodgepole (lower Paine Member) and Allan Mountain Limestones at 31 localities and consists of nearly 1,200 specimens belonging to four blastoid genera (*Tanaoblastus*, *Strongyloblastus*, *Orophocrinus*, and *Metablastus*). A second fauna occurs in the middle Lodgepole Limestone (upper Paine Member) at four localities where about 195 specimens and five blastoid genera occur (*Koryschisma*, n. gen., *Montanablastus*, n. gen., *Strongyloblastus*, *Cryptoblastus*?, and *Hadroblastus*). The highest fauna occurs near the top of the Lodgepole Limestone (upper Woodhurst Member) at three localities in the Bridger Range and is represented by 19 specimens and three blastoid genera (*Cryptoblastus*?, *Orophocrinus*, and *Phaenoschisma*).

Most of the blastoids in these faunas are fairly well silicified, and, when extracted with heated acetic acid, a few show excellent preservation of plate ornament and ambulacral structures. One blastoid occurrence in the middle Lodgepole has calcitic specimens with complete brachioles and attached stem segments that lack distal attachment structures. The Lodgepole blastoid faunas appear to be middle Kinderhookian to early Osagean (early to middle Tournaisian) in age, and are most similar to other Early Mississippian (or earliest Carboniferous) blastoid faunas in Missouri, Alberta, New Mexico, and Belgium. The diverse lower Lodgepole fauna is dominated by a small globular spiraculate (*Tanaoblastus*) at nearly all sections, whereas other pyramidal, elongate, and club-shaped spiraculate or fissiculate blastoids are much less common. Most of these blastoids were apparently attached, medium-level, suspension feeders living on a lime mud bottom in a carbonate ramp setting near or well below normal wave base. At several localities, members of the lower and middle Lodgepole blastoid faunas are found adjacent to or just below Waulsortian-type bioherms.

New taxa include the fissiculates *Koryschisma elegans*, n. gen., n. sp., and *Orophocrinus macurdai*, n. sp., and the spiraculates *Metablastus milliganensis*, n. sp., *Strongyloblastus breimeri*, n. sp., *S. laudoni*, n. sp., *Montanablastus baldyensis*, n. gen., n. sp., and *Tanaoblastus allanensis*, n. sp.

INTRODUCTION

Blastoids are usually considered a relatively rare element in the Early Mississippian faunas of the northern Rocky Mountain region in the western United States. Only four blastoid species from the Early Mississippian of this region have been described in the 120 years between 1865 and 1985. However, several authors have reported the presence of unidentified blastoids in faunal lists during this period. Between 1963 and 1968, we made an extensive collection of blastoids from the Lodgepole and Allan Mountain Limestones of Early Mississippian age in western Montana and adjacent states. This new material and a restudy of previously described specimens form the basis for this paper.

The present authors independently discovered blastoids in the Early Mississippian of western Montana during the summers of 1962 and 1963. During the following three summers (1964–66), we returned to Montana to work together on the biostratigraphy and paleontology of the Sappington Member of the Three Forks Formation and the Lodgepole Limestone under NSF-sponsored grants (see Acknowledgments; Sprinkle, 1965; Sprinkle

[1] Department of Geological Sciences, University of Texas, Austin, Texas 78713-7909.

[2] Department of Earth Sciences, University of Notre Dame, Notre Dame, Indiana 46556-1020 (Present address: 2901 Leonard, Medford, Oregon 97504).

TABLE 1. LIST OF COLLECTING LOCALITIES WHERE WE COLLECTED BLASTOIDS FROM THE LODGEPOLE AND ALLAN MOUNTAIN LIMESTONES IN WESTERN MONTANA AND SOUTHEASTERN IDAHO. LOCALITIES FOR BORROWED USGS SPECIMENS (SQUAW CREEK, GALLATIN RANGE; OLD BALDY, GRAVELLY RANGE; AND BRAZER →

Locality	Code	Range	Land-grid location
Antelope Valley	AV		SW, NE, NE, sec. 2, T1S, R2W
Ant Park	AP	Little Belt Mtns.	NW, SW, sec. 35, T12N, R9E
Bacon Rind Creek	BA	Gallatin Range	SE, SE, sec. 22, T10S, R5E
Baldy Mountain	BY	Bridger Range	NW, SE, sec. 11, T1S, R6E
Bandbox Mountain	BD	Little Belt Mtns.	NE, NW, sec. 20, T14N, R10E
Bridger Mountain	BG	Bridger Range	SW, NE, sec. 11, T1S, R6E
Brownback Gulch	BB	Tobacco Root Mtns.	NE, NW, SE, sec. 20, T1S, R3W
Cowboy Canyon	CB	Madison Range	SE, NW, sec. 27, T4S, R2E
Crown Mountain	CR	Lewis & Clark Mtns.	C, SW, sec. 28, T19N, R9W
Dry Hollow	DH		SW, NE, sec. 3, T1N, R1W
Dudley Creek	DC	Madison Range	NW, SE, sec. 32, T6S, R4E
Ellis Mountain (Ellis Peak)	EM	Gallatin Range	NW, SE, sec. 14, T3S, R6E
Gallop Creek	GP	Bridger Range	SE, SW, sec. 11, T3N, R5E
Grendah Mountain	GH	Little Belt Mtns.	SE, NE, NW, sec. 31, T13N, R9E
Jordan Creek	JC	Madison Range	W½, sec. 23, T5S, R1E
Little Antelope Creek	LA	Tobacco Root Mtns.	S½, sec. 27, T1S, R2W
London Hills	LH		N½, NW, sec. 4, T1S, R2W
Milligan Canyon	MC		NE, SW, sec. 36, T2N, R1W
Milligan Canyon East	MC(E)		NE, SW, sec. 31, T2N, R1E
North Frazier Lake	FR	Bridger Range	NW, SE, sec. 9, T2N, R6E
North Sawtooth Mountain	NS	Lewis & Clark Mtns.	SW, NE, sec. 13, T21N, R9W
Northeast Baldy Mountain	NB	Bridger Range	SE, SE, SE, sec. 2, T1S, R6E
Pole Canyon	PC	Tobacco Root Mtns.	SW, sec. 8, T1S, R3W
Roy Gulch	RG	Horseshoe Hills	NW, NW, sec. 28, T4N, R4E
Sacagawea Peak	SA	Bridger Range	SE, NW, sec. 27, T2N, R6E
Saddle Peak	SP	Bridger Range	E½, NE, sec. 35, T1S, R6E
Sand Creek	SC		SW, NE, sec. 4, T1S, R1W
Sixteen Mile Creek	SX	Horseshoe Hills	SE, SW, sec. 4, T4N, R3E
South Boulder	SB	Tobacco Root Mtns.	SE, SW, sec. 20, T1S, R2W
Squaw Creek Ranger Station	SQ	Gallatin Range	NW, NE, sec. 28, T4S, R4E
Standard Creek	ST	Gravelly Range	NE, SE, sec. 6, T11S, R1W
Targhee Peak	TG	Henrys Lake Mtns.	NE, SW, SW, sec. 9, T16N, R43E
Timber Butte	TB	Gallatin Range	NE, SE, sec. 11, T5S, R5E

and Gutschick, 1967; Gutschick, McLane, and Rodriguez, 1976; Sprinkle and Gutschick, 1983). This research resulted in the discovery that blastoids are relatively common and diverse in the basal part of the Lodgepole and Allan Mountain Limestones over much of western Montana and that they are also present at two higher levels in the Lodgepole. Blastoids have now been found at 33 sections (Table 1) in southwestern, west-central, and northwestern Montana and in southeastern Idaho (Text-Fig. 1), and are undoubtedly present at many other localities in western Montana and adjacent states. During these three summers of field work and shorter visits in 1967 and 1968, we collected more than 1,400 blastoid specimens, belonging to nine genera and 16 species.

PREVIOUS STUDIES OF MADISON GROUP STRATIGRAPHY

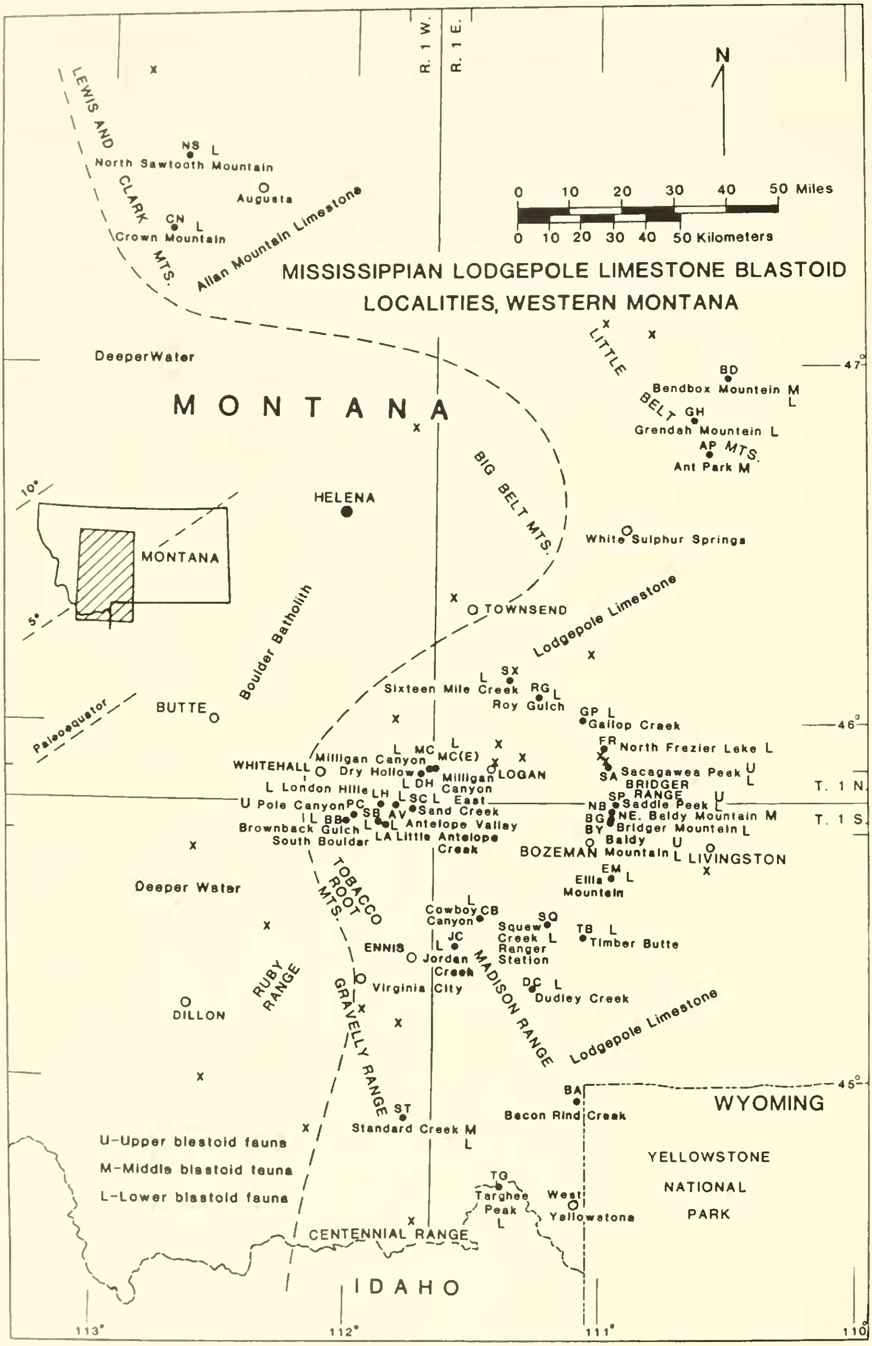
The Madison Group in western Montana is made up of the thinner-bedded Lodgepole Limestone below (Text-Fig. 2) and the overlying more massive-bedded Mission Canyon Limestone. Together these two units represent 750 ft (229 m) to more than 2,000 ft (610 m) of Early and Middle Mississippian tropical-shelf carbonates. Lodgepole thicknesses range from about (*continued*) CANYON, NORTHERN UTAH) ARE NOT INCLUDED BECAUSE WE DID NOT VISIT OR COLLECT BLASTOIDS THERE. ABBREVIATIONS FOR BLASTOID GENERA INCLUDE: C = *CRYPTOBLASTUS*?, H = *HADROBLASTUS*, K = *KORYSCHISMA*, M = *METABLASTUS*, MO = *MONTANABLASTUS*, O = *OROPHOCRINUS*, P = *PHAENOSCHISMA*?, S = *STRONGYLOBLASTUS*, AND T = *TANAOBLASTUS*.

Topographic map	County	State	Fauna	Blastoid composition
Jefferson Island	Madison	Mont.	Lower	4 T, 1 M
Sand Point	Meagher	Mont.	Middle?	1 S, 1 K?
Tepee Creek	Gallatin	Mont.	Lower	1 T
Sedan	Gallatin	Mont.	Lower, Upper	3 T; 1 O, 1 C
Bandbox Mountain	Judith Basin	Mont.	Lower, Middle	8 T; 27 K, 4 C
Sedan	Gallatin	Mont.	Lower	8 T
Waterloo	Madison	Mont.	Lower	1 T
Ancenney	Madison	Mont.	Lower	14 T
Choteau	Lewis & Clark	Mont.	Lower	174 T
Three Forks	Jefferson	Mont.	Lower	21 O, 1 S, 1 T
Spanish Peaks	Gallatin	Mont.	Lower	1 T
Mystic Lake	Gallatin	Mont.	Lower	14 T
Maudlow	Gallatin	Mont.	Lower	10 T
King's Hill	Judith Basin	Mont.	Lower	1 T
Ennis	Madison	Mont.	Lower	10 T
Harrison	Madison	Mont.	Lower	25 T, 2 O
Jefferson Island	Madison	Mont.	Lower	220 T, 1 M
Three Forks	Jefferson	Mont.	Lower	17 S, 2 O, 1 T, 1 M
Three Forks	Broadwater	Mont.	Lower	19 S, 15 O, 5 T, 2 M
Sedan	Gallatin	Mont.	Lower	25 T
Sawtooth Ridge	Lewis & Clark	Mont.	Lower	2 T
Sedan	Gallatin	Mont.	Lower, Middle	4 T, 2 M; 29 Mo, 10 S, 1 C
Whitehall	Madison	Mont.	Upper?	1 C
Maudlow	Gallatin	Mont.	Lower	2 T
Sedan	Gallatin	Mont.	Lower, Upper	2 T; 11 C, 1 K?
Sedan	Gallatin	Mont.	Lower, Upper	1 T, 1 S; 1 P
Three Forks	Gallatin	Mont.	Lower	1 O
Toston	Broadwater	Mont.	Lower	7 T
Harrison	Madison	Mont.	Lower	2 T, 2 S
Garnet Mountain	Gallatin	Mont.	Lower	18 T
Monument Ridge	Madison	Mont.	Lower, Middle	437 T, 2 O, 1 S; 1 H
Targhee Peak	Fremont	Idaho	Lower	51 T, 1 S
Garnet Mountain	Gallatin	Mont.	Lower	8 T

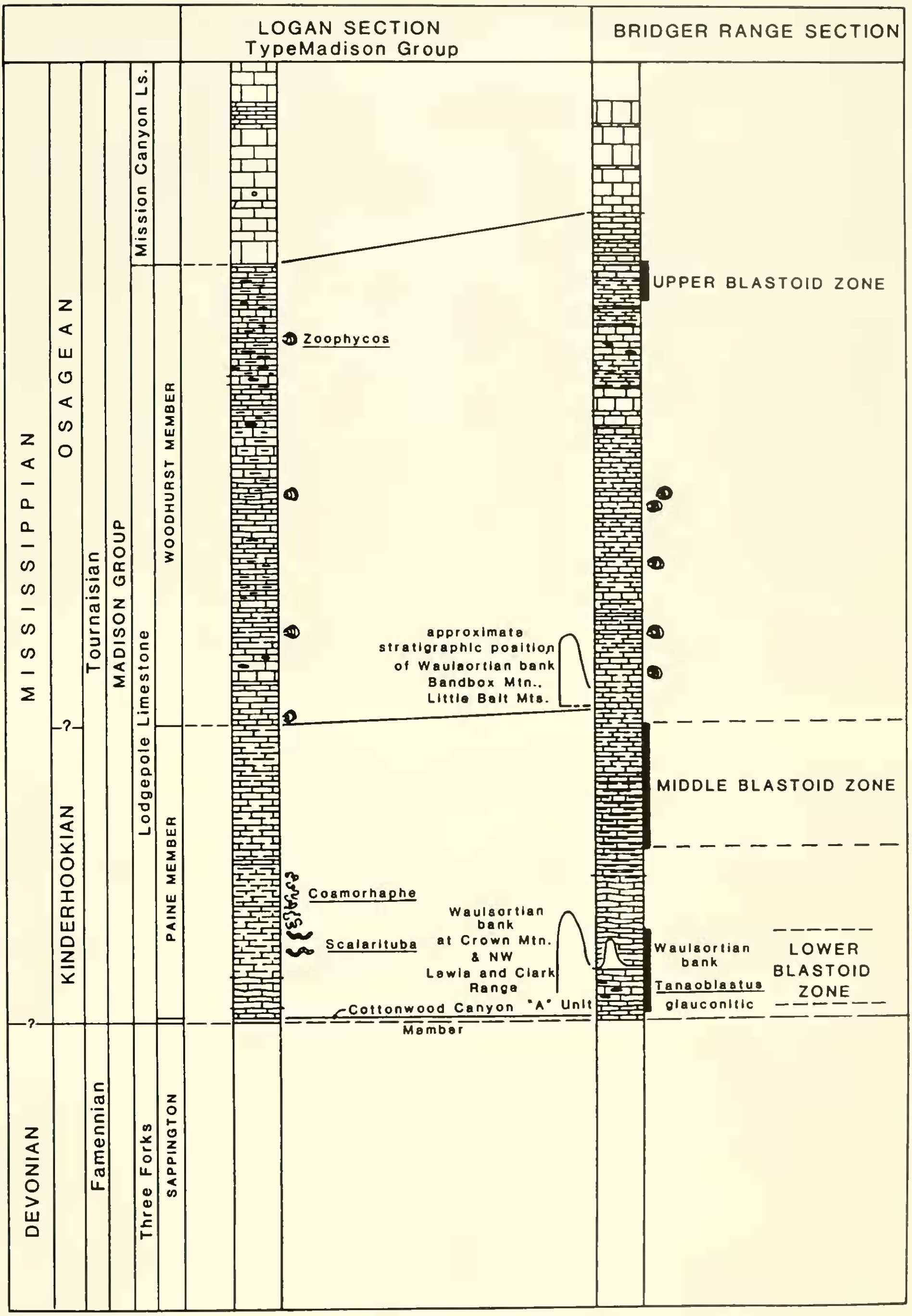
500 ft (152 m) to more than 1,000 ft (305 m) (Gutschick, McLane, and Rodriguez, 1976, pp. 107–108, figs. 8-12, 8-13). These competent structurally-deformed rocks commonly form the backbone and crest of many mountain ranges (Text-Figs. 3–6). The enormous volume of carbonate rock and the physiographic obstacles make access, observation, and collection difficult for depositional and paleontological field studies. Nevertheless, many local and regional contributions have been published for Montana.

Some useful studies of the Lodgepole Limestone which contains the blastoid faunas described here include the following: Sloss and Hamblin, 1942; Laudon and Severson, 1953; Andrichuk, 1955; Roberts, 1966; Wilson, 1969; Sando, Mamet, and Dutro, 1969; Craig, 1972; Smith, 1972, 1977; Sando and Dutro, 1974; Sando, 1976; Rose, 1976; Gutschick, McLane, and Rodriguez, 1976; Roberts, 1979; Gutschick, Sandberg, and Sando, 1980; and Sandberg and Gutschick, 1983, 1984.

Studies of the Allan Mountain Limestone in the Sun River area include: Sloss and Laird, 1945; Mudge, Sando, and Dutro, 1962; and Haines, 1977. Several occurrences of Waulsortian-like bioherms are known from the lower and middle Lodgepole Limestone and are discussed in



Text-Figure 1. Map of western Montana and adjacent states showing the location of the 33 sections (black dots) where the authors collected blastoids from the Lodgepole and Allan Mountain Limestones between 1962 and 1968. Dashed line shows boundary between fossiliferous, shallow-water environments in the lower Lodgepole Limestone to the east, and nearly unfossiliferous, deeper-water environments further west. No blastoids were found at localities marked with X's.



Text-Figure 2. Generalized measured section of the Lodgepole Limestone at Logan (type section of the Madison Group) and in the Bridger Range showing where the lower, middle, and upper blastoid faunas have been found. Position of Waulsortian banks and trace fossil facies are also marked.

Text-Figure 3. View of the north flank of Sacagawea Peak (SA) in the northern Bridger Range from the peak just to the north. The Lodgepole and Mission Canyon Section was measured along the ridge on the skyline. Right arrow points to base of Lodgepole Limestone just below where *Tanaoblastus* occurs; left arrow points to beds on crest about 655 ft (200 m) above base of Lodgepole where *Cryptoblastus*? sp. A found. Zig-zag trail up to pass at back of cirque is visible in right foreground. See McMannis (1955).

Cotter, 1965, 1966; Stone, 1972; and Smith, 1977, 1982.

PRESERVATION AND PREPARATION

Nearly all of the specimens in the lower Lodgepole blastoid fauna are silicified, which made possible their discovery and collection in the field and their extraction from the surrounding limestone matrix in the laboratory. At most sections, the blastoids are very well silicified, having the endoskeleton completely replaced by silica, and even the delicate internal hydrospires are often well-preserved. In different specimens, the interior cavity of the blastoid is hollow, partly filled with secondary quartz crystals, or completely filled with cryptocrystalline chalcedony, the last condition occurring most commonly where the blastoids are closely associated with nodular chert. The blastoids appear to be one of the better silicified members of the fauna at most of the sections where they are found.

At a few sections, especially North Frazier Lake (FR) in the Bridger Range, Roy Gulch (RG) in the Horseshoe Hills, and North Sawtooth Mountain (NS) in Sun River Canyon, northwestern Montana (see Text-Fig. 1), specimens of *Tanaoblastus* are only slightly or partly silicified, making their extraction from the surrounding limestone matrix very difficult. In these specimens, the silicification occurs either as patches in the endoskeleton or as a thin skin of silica that is easily broken through during acid preparation.

Nearly all the collected blastoids that appeared to be well silicified were extracted from the surrounding limestone matrix by the use of either heated acetic acid or cold dilute hydrochloric acid. During the early stages of this project, it was discovered that many of the silicified blastoids could be recovered in much better condition by using acetic acid instead of the faster-working hydrochloric acid, and acetic acid was used in all of the later work.

Text-Figure 4. View of the southern Bridger Range taken from the southwest flank of Saddle Peak (SP). Northeast Baldy Mountain (NB) collecting locality is on the ridge crest (arrow) with Baldy and Bridger Mountains just to the south. Long ridge crest here is made up of thin-bedded Lodgepole Limestone generally dipping to the east. Two small Waulsortian bioherms in the lower Lodgepole (white patches labelled with W's) can be seen on the west-facing scarp face just north of Northeast Baldy. See Skipp and McMannis (1971).

Text-Figure 5. View of the west face of Bandbox Mountain (BD) in the northern Little Belt Mountains showing elongate Waulsortian bioherm or bank (white cliff) just below skyline. Original *Koryschisma* block found loose in talus chute at base of Lodgepole Limestone measured section at lower arrow; lithology was traced up to beds at 170–175 ft (52–53 m) above base where additional specimens collected in chute and on ridge crest (two upper arrows).

Text-Figure 6. View of the Upper Devonian and Lower Mississippian section on the north face of Crown Mountain (CM) in the Lewis and Clark Mountains of northwestern Montana. Cliffed part of the exposure (the mountain's "crown") is the lower Allan Mountain Limestone bearing *Tanaoblastus allanensis*, n. sp.

One of the major problems of using acetic acid, its slow reaction with the limestone matrix, was partly overcome either by heating the acid on a hotplate to a temperature between 110° and 130° F or by starting with hot water at this temperature. This elevated temperature increased the rate of reaction of acetic acid to about two-thirds the rate of cold, dilute hydrochloric acid, but still yielded excellent preservation.

At some of the Lodgepole blastoid localities, there is a marked contrast between the type of preservation developed during natural weathering and that achieved by extraction using heated acetic acid. The best example of this condition is found at the Standard Creek Section (ST) on the slopes of Cave Mountain in the Gravelly Range of southwestern Montana (see Text-Fig. 1), where nearly 500 specimens of *Tanaoblastus* have been collected. Natural weathering of these blastoids has produced a rather coarse, granular, pitted surface on the exposed portions of nearly all these specimens that has destroyed much of the finer detail of the ambulacra, oral and anal regions, and calyx ornamentation. If these specimens are extracted from the surrounding limestone matrix by using heated acetic acid, in most specimens the unweathered parts are somewhat better preserved than the weathered parts. In about 20% of the specimens, there is an extreme contrast in preservation (see Plate 1, Fig. 1). In these specimens, the unweathered parts of the theca show excellent preservation and remarkably fine detail, especially of the ambulacral areas and thecal ornament, in contrast to the naturally weathered parts. The preserved detail on these acid-extracted, silicified specimens appears to be equal to that found on the best-preserved calcitic blastoids from other localities.

It is not clear why this contrast in preservation is present, or why it occurs only at certain Lodgepole localities. This same difference in preservation was also found at the Dry Hollow (DH) and Milligan Canyon East (MC[E]) Sections (see Text-Fig. 1), where some of the specimens of *Orophocrinus*, *Strongyloblastus*, and *Metablastus* show the same contrast (see Plate 1, Figs. 2–5). However, at the nearby London Hills Section (LH), only 10 miles (16 km) to the west, where specimens of *Tanaoblastus*, *Strongyloblastus*, and *Metablastus* have been found, the fossils are well silicified but the preservation is rather poor on all of the specimens no matter if weathered or extracted with hydrochloric acid or heated acetic acid. This difference in preservation appears to be primarily controlled by the nature and degree of silicification of the blastoids themselves (including the hollow interiors), but apparently is also influenced by the degree of weathering and type of natural exposure, and by the nature of the surrounding limestone matrix. Etching by lichens may be another factor degrading the quality of silicified specimens during natural weathering.

One locality in the middle Lodgepole has weakly silicified blastoid specimens with delicate appendages (brachioles and stem segments) still attached. Many of these specimens on limestone slabs were uncovered and cleaned using an S. S. White air abrasive unit with dolomite powder. Two specimens from this locality and a few silicified or unsilicified specimens from other localities were ground down using abrasives on a glass plate to obtain information on the summit and internal structures of the theca.

PREVIOUS STUDIES OF MADISON BLASTOIDS

Only three short taxonomic articles describing a total of three blastoid species from the Early Mississippian of the northern U.S. Rocky Mountains have been published in the last 120 years (Meek, 1873; Hambach, 1903; Clark, 1917). However, during this period, at least five other authors have reported the presence of unstudied blastoids in faunal lists from the Lower Mississippian formations in this region (White, 1879; Laudon and Severson, 1953; Mudge, Sando, and Dutro, 1962; Sando and Dutro, 1980), indicating that blastoids may be a more common element in the faunas than usually thought. One of these occurrences from the Sappington Member of the Three Forks Formation (Gutschick, Suttner, and Switek, 1962, p. 82), now considered Late Devonian, was studied in detail by the present authors (Sprinkle and Gutschick, 1966, 1967). Other previously reported Mississippian blastoid occurrences appear to be from the overlying Madison Group (and its equivalents).

Meek (1873, p. 470) was the first author to describe a blastoid, *Pentremites bradleyi*, from the "Madison Formation" of the northern Rocky Mountains. Hambach (1903) restudied Meek's three specimens deposited in the Smithsonian Institution and, in addition to redescribing two of the specimens under the original name, designated the third specimen as a new species in a different genus, *Cribroblastus schucherti*. Clark (1917, pp. 361–373) reviewed all the previous reports of blastoids in the northern Rockies, and described a new species from the "Madison limestone" under the name *Schizoblastus haynesi*. Unfortunately, no summit (oral) views of either of his figured type specimens were presented in this paper, and this has resulted in some subsequent confusion about their correct generic assignment. Clark mentioned (p. 362) that White (1879, p. 80) had reported the occurrence of *Schizoblastus lotoblastus* from the Teton Range in western Wyoming, and Clark also described (pp. 369–370) a poorly preserved blastoid from "Old Baldy, near Virginia City, Montana" (Gravelly Range) as *Pentremites conoideus*. No additional blastoid material was mentioned until Laudon and Severson (1953, fig. 2a) listed *Cryptoblastus* in a measured section of the Lodgepole Limestone (lower Madison Group) from the Bridger Mountains of southwest Montana. Mudge, Sando, and Dutro (1962, p. 2017) listed *Pentremites* sp. in a faunal list from the Castle Reef Dolomite (an upper Madison equivalent) in the Sun River Canyon area of northwestern Montana. Sando and Dutro (1980, p. 42) listed *Cryptoblastus* sp. in a faunal list for the lower Lodgepole Limestone from the northern Gravelly Range of southwestern Montana, probably the same Baldy Mountain locality as given above by Clark.

During the past fifty years, there has been much confusion about the true generic assignment of Clark's and Hambach's described species. In 1937, Fritz and Cline reported the occurrence of small globular blastoids from the Mississippian Banff Shale or Rundle Limestone on Mt. Coleman in western Alberta; additional blastoids from the Banff in the Sunwapta Pass area were reported by Laudon, Parks, and Spreng (1952). Fritz and Cline compared their Canadian material to Clark's Montana specimens, and kept his specific name, but reassigned both groups of specimens to the genus *Mesoblastus* on the basis of their material (Fritz and Cline, 1937, p. 309). Unfortunately, they did not restudy Clark's original types, but relied on the incomplete set of photographs in his 1917 paper. Peck (1938, p. 57), in a study of the blastoid fauna of the Chouteau Formation in Missouri, remarked that Clark's Montana specimens closely resembled some of his Missouri specimens of Kinderhookian age then assigned to the genus *Cryptoblastus*, but declined to consider the Montana specimens any further because of Fritz and Cline's assignment of these specimens to *Mesoblastus* during the previous year. In 1961, Fay restudied both Peck's *Cryptoblastus* material from the Chouteau of Missouri and Clark's holotype from Montana (MCZ 347) and assigned both forms to his new genus *Tanaoblastus* along with a single lower Burlington Limestone species from Missouri (Fay, 1961, pp. 101–104). However, *Tanaoblastus* and *Cryptoblastus* appear to be very closely related and there is still some question as to the correct assignment of certain species now assigned to each of these genera.

Galloway and Kaska (1957) reviewed the genus *Pentremites* and assigned Meek's *P. bradleyi* to their *Pentremites sulcatus* group (p. 74) because of its described slightly concave ambulacra, but they did not restudy the type specimens deposited in the Smithsonian Institution. Macurda (1962, pp. 1372–1373; 1978, p. 1293) in a discussion of Hambach's form "*Schizoblastus*" *schucherti*, mentioned that the original suite of specimens came from Idaho near the Montana border, and in 1978 provisionally assigned these forms to *Cribroblastus cornutus*. Luke and Moyle (1976) reported a similar occurrence of this species in the Brazer Formation of northern Utah,

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PLATE 1

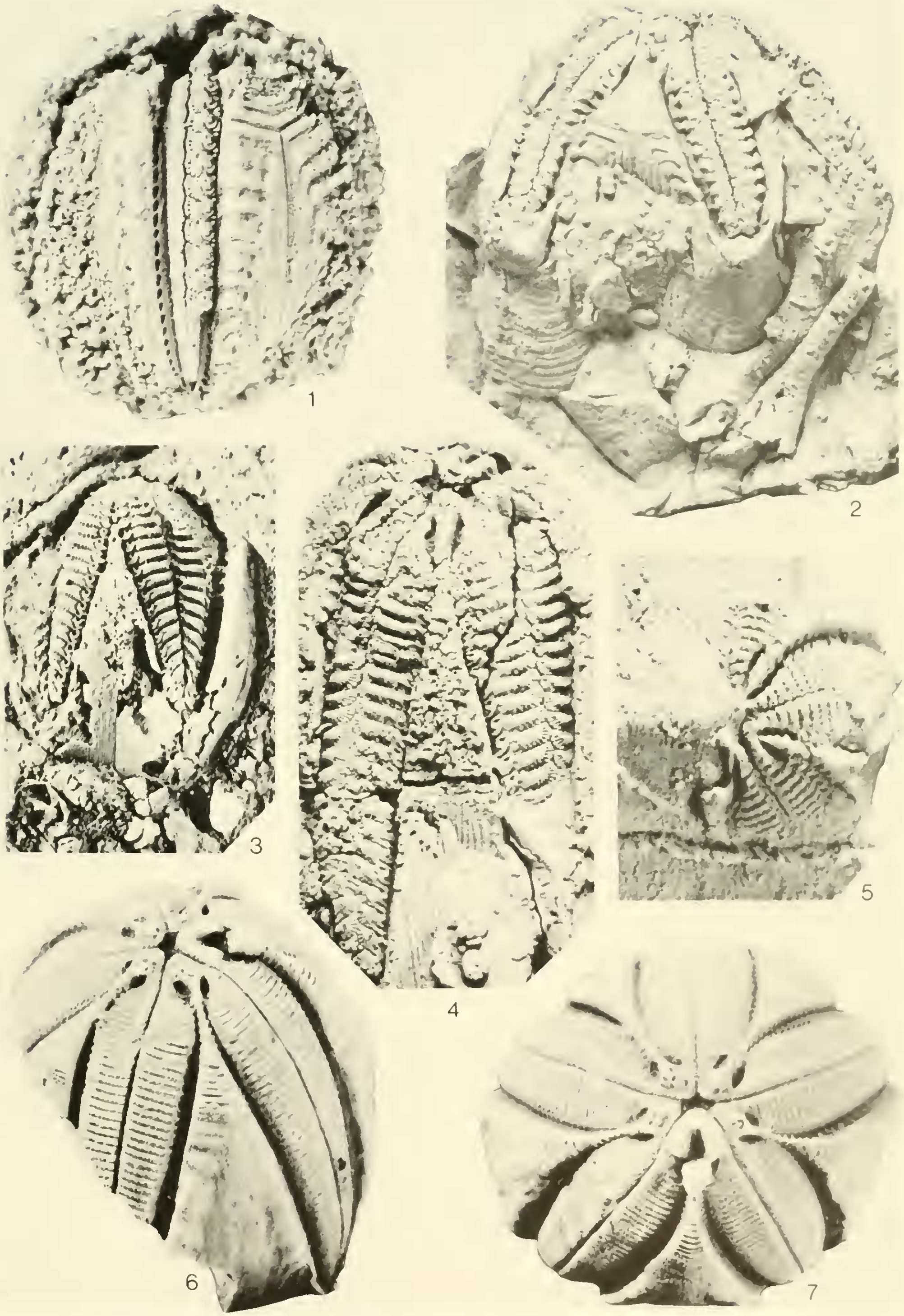
Figure 1. *Tanaoblastus haynesi* (Clark), lower Paine Member, lower Lodgepole Limestone, Standard Creek, southwestern Montana; side view of small theca MCZ 1024 showing contrast between coarse surface produced by natural weathering (around edges) and excellent preservation of ambulacral features and plate ornament formed by acetic acid etching (in center), ×12.

Figure 2. *Orophocrinus macurdai* Sprinkle and Gutschick, n. sp., lower Paine Member, lower Lodgepole Limestone, Dry Hollow, southwestern Montana; B-side view of partly-etched paratype MCZ 823 in slab; note excellent preservation of ambulacra, spiracular slits, and radial and deltoid ornament, ×6.3.

Figure 3. *Strongyloblastus laudoni* Sprinkle and Gutschick, n. sp., upper Paine Member, middle Lodgepole Limestone, Northeast Baldy Mountain, southwestern Montana; side view of paratype MCZ 878 in slab showing well-preserved ambulacra and growth lines on radials, ×6.

Figures 4–5. *Strongyloblastus breimeri* Sprinkle and Gutschick, n. sp., lower Paine Member, lower Lodgepole Limestone, Dry Hollow and Milligan Canyon East, southwestern Montana; 4, oblique EA-side view of paratype MCZ 854; note well-preserved ambulacra, spiracles, and growth lines on radials, ×7.5; 5, top view of paratype MCZ 849 still partly embedded in matrix showing C-spiracle cut off from rest of anispiracle by thin epideltoid septum (compare with 7 below), ×9.

Figures 6–7. *Strongyloblastus petalus* Fay, Banff Formation, western Canada; oblique DE-side and top views of partly-complete large theca UMR 6967 (Spreng Collection); note excellent preservation, wide ambulacra with curved food grooves near mouth, ridged deltoids, regular spiracles separated by raised deltoid septa, and very large horseshoe-shaped epideltoid that connects on right side with raised hypodeltoid cutting off C-spiracle from central anus but leaving D-spiracle barely connected, ×3.7.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a unit that has produced several other Late Mississippian blastoids (see Peck, 1930).

LODGEPOLE AND ALLAN MOUNTAIN BLASTOID FAUNAS

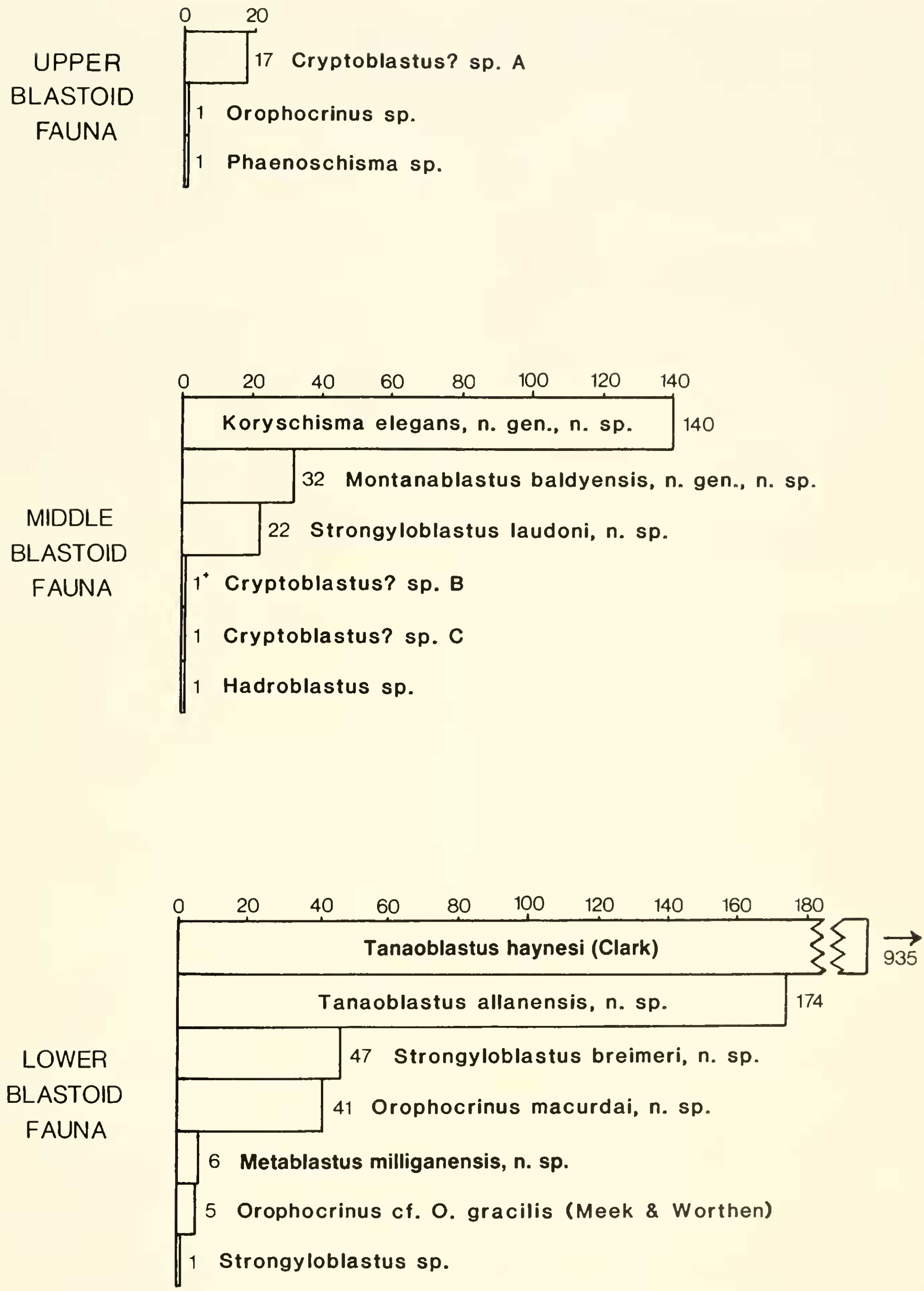
Lower Lodgepole Blastoid Fauna

The lower Lodgepole blastoid fauna is the most abundant, widespread, and diverse fauna known from the Rocky Mountains. This fauna has been found in the fossiliferous cherty beds between 5 and 75 ft (1.5–23 m) above the base of the Lodgepole and Allan Mountain Limestones (Text-Fig. 2) at 31 sections in southwestern, west-central, and northwestern Montana and in extreme southeastern Idaho (Text-Fig. 1). This blastoid fauna consists of four genera (*Tanaoblastus*, *Orophocrinus*, *Strongyloblastus*, and *Metablastus*) and seven species. About 1,220 specimens of this fauna were collected during four summers of field work (1963–66) and several later visits. This blastoid fauna is characterized by the dominance of the small globular genus *Tanaoblastus* overshadowing the other members of the fauna over its entire range. *Tanaoblastus* is by far the most abundant blastoid in the fauna, with 1,109 specimens (91% of the entire fauna) vs. 48 specimens (4%) for *Strongyloblastus*, 46 specimens (3.8%) for *Orophocrinus*, and six specimens (0.5%) for *Metablastus* (Text-Fig. 7). *Tanaoblastus* is also by far the most widespread, highest- and lowest-ranging form in the zone, and usually the dominant blastoid at any particular section. However, at a small number of Lodgepole sections just west of Three Forks in southwestern Montana, *Tanaoblastus* is a minor element and its place is taken by *Orophocrinus* and *Strongyloblastus*, with *Metablastus* also appearing rarely at these sections (Text-Fig. 8).

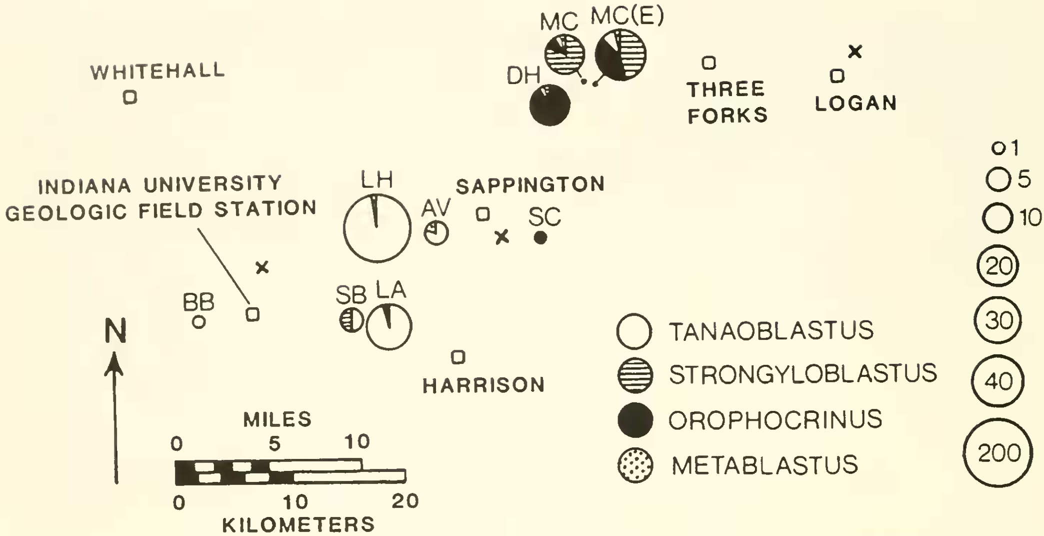
Middle Lodgepole Blastoid Fauna

Blastoids have been found between 110 and 200 ft (34–61 m) above the base of the Lodgepole at four scattered localities in southwestern and central Montana. The five genera and six species from these levels have been grouped together and collectively designated as the middle Lodgepole blastoid fauna (Text-Fig. 7). However, no more than three of these genera apparently occur together at any one section, and the four known occurrences may be at significantly different stratigraphic levels. One large group of specimens (about 50) has been found at three sections in the Bridger Range in southwestern Montana. Four specimens were collected in the early 1950s by Lowell R. Laudon from 110 to 125 ft (34–38 m) above the base of the Lodgepole from the Fairy Lake and Cottonwood Canyon Sections; these were listed as "*Cryptoblastus*" at this level in a stratigraphic section (Laudon and Severson, 1953, p. 509). At Laudon's suggestion, we visited a long exposure on the crest of the Bridger Range just north of Baldy Mountain (the Northeast Baldy Section [NB] in Text-Figs. 1 and 4) during the summer of 1966, and collected over 45 additional specimens, some partly silicified but many still calcitic with attached stems and brachioles. Three genera are present: *Strongyloblastus*, *Montanablastus*, n. gen., and *Cryptoblastus*? Unfortunately, we were not able to determine the exact position of this horizon because of faulting between the NB blastoid locality and the base of the Lodgepole about half a mile (0.8 km) to the south, but it is thought to be about 150 to 175 ft (46–53 m) above the base of the Lodgepole.

A second blastoid locality in the middle Lodgepole was discovered in August 1966 at Bandbox Mountain (BD) (Text-Figs. 1 and 5) in the northern Little Belt Mountains of west-central Montana. A large float block bearing a single exposed silicified blastoid was discovered in a talus chute at the base of the Lodgepole section and traced back up to a series of massive black beds between 170 and 175 ft (52–53 m) above the base. However, only a few additional specimens could be collected in place, and instead the talus block, weighing about 30 lb (13.6 kg), was carried out intact and shipped back to Harvard Uni-



Text-Figure 7. Bar graph showing the composition of the three blastoid faunas in the Lodgepole and Allan Mountain Limestones. Note abundance and diversity of these faunas and dominance of the lower blastoid fauna by *Tanaoblastus haynesi*; at true scale, its bar would extend nearly five times further to the right.



Text-Figure 8. Detailed map of the west-central part of the study area showing the abundance of different blastoid genera in the lower Lodgepole blastoid fauna. Note that *Tanaoblastus* is the dominant genus at many sections, but is replaced as most common by *Orophocrinus* and *Strongyloblastus* at three sections just west of Three Forks.

versity, in the hope that additional blastoids could be recovered by acid etching. The results proved to be well worth the effort (see Text-Fig. 9 and Plate 2). More than 35 complete and fragmentary specimens and several hundred separate plates of the new fissiculate genus *Koryschisma* were recovered from this block in addition to four plates and fragments of a small globular spiraculate blastoid, here designated as *Cryptoblastus*? sp. B. *Koryschisma* is the first fissiculate blastoid of the Phaenoschismatidae to be discovered in the northern Rockies, and because of the excellent preservation of these silicified specimens and separate plates, is probably the most completely known genus of the entire family. Two additional blastoid specimens, apparently from the middle Lodgepole, were recently collected by the late James Welch near Ant Park in the central Little Belt Mountains (see Plate 5, Fig. 9).

The last member of the middle Lodgepole blastoid fauna is a single specimen of *Hadroblastus* sp. from the Standard Creek Section (ST) in extreme southwestern Montana. This specimen was found on a small slab of crinoids on the talus slope above the lower cliff on Cave Mountain where *Tanaoblastus* is abundant. The top of the exposed Lodgepole beds at this locality is about 250 ft (76 m) above the base, so that this single specimen could have come from anywhere between 100 and 250 ft (30–76 m) above the base. The single calcite specimen has the proximal stem and a few of the brachioles preserved and was further uncovered using an air abrasive unit.

Upper Lodgepole Blastoid Fauna

The 19 specimens of the upper Lodgepole blastoid fauna are only known from the Bridger Range in southwestern Montana. The three genera and species in this fauna are very unequally represented because two of the genera are known from only a single specimen apiece. Fifteen specimens (mostly fragmentary) of *Cryptoblastus*? sp. A were found in a single bed at 655 ft (200 m) above the base of the Lodgepole along the sloping ridge east of the Sacagawea Peak Section (SA) (Text-Fig. 3) in the northern Bridgers; two additional specimens thought to represent this same form were found on a ripple-marked limestone surface exposed in place in a small saddle near the Baldy Mountain Section (BY) (Text-Fig. 4) in the southern Bridgers, along with a single specimen of *Orophocrinus* sp. This bed appears to be near the top of the Lodgepole (probably in the upper 200 ft or 61 m), but its exact position could not be determined. A single specimen of *Phaenoschisma*? sp. was found in the float on the north flank of Saddle Peak in the southern Bridgers; it also appears to have come from the upper 200 ft (61 m) of the Lodgepole. The Lodgepole Limestone is about 800 ft (244 m) thick in the southern Bridgers, so that all of the specimens in the upper Lodgepole blastoid fauna probably came from beds between 600 and 800 ft (183–244 m) above the base of the formation (see Text-Fig. 2).

Both the middle and upper Lodgepole blastoid faunas are less well known than the abundant and widespread lower Lodgepole blastoid fauna, implying that these younger faunas could be considerably more diverse than is presently known. We found no blastoids between 200 and 600 ft (61–183 m) above the base of the formation, although fossiliferous and apparently favorable beds are present at several sections. Additional blastoid genera and localities will probably be found in the upper part of the Lodgepole in western Montana and adjacent areas as more field work is done on these units.

Text-Figure 9. Partly etched, original block from the middle Lodgepole Limestone at Bandbox Mountain (BD) showing the abundance of *Koryschisma* thecae, plates, flanged columnals, and brachiole fragments in some beds. Complete specimens include (from left edge): unnumbered cracked theca, MCZ 925 (above), MCZ 921 covered with debris, large holotype MCZ 915, the base of which was the only identifiable blastoid part originally exposed, broken MCZ 927 (above), and MCZ 926. Millimeter and centimeter scale at lower right.

OCCURRENCE AND DISTRIBUTION

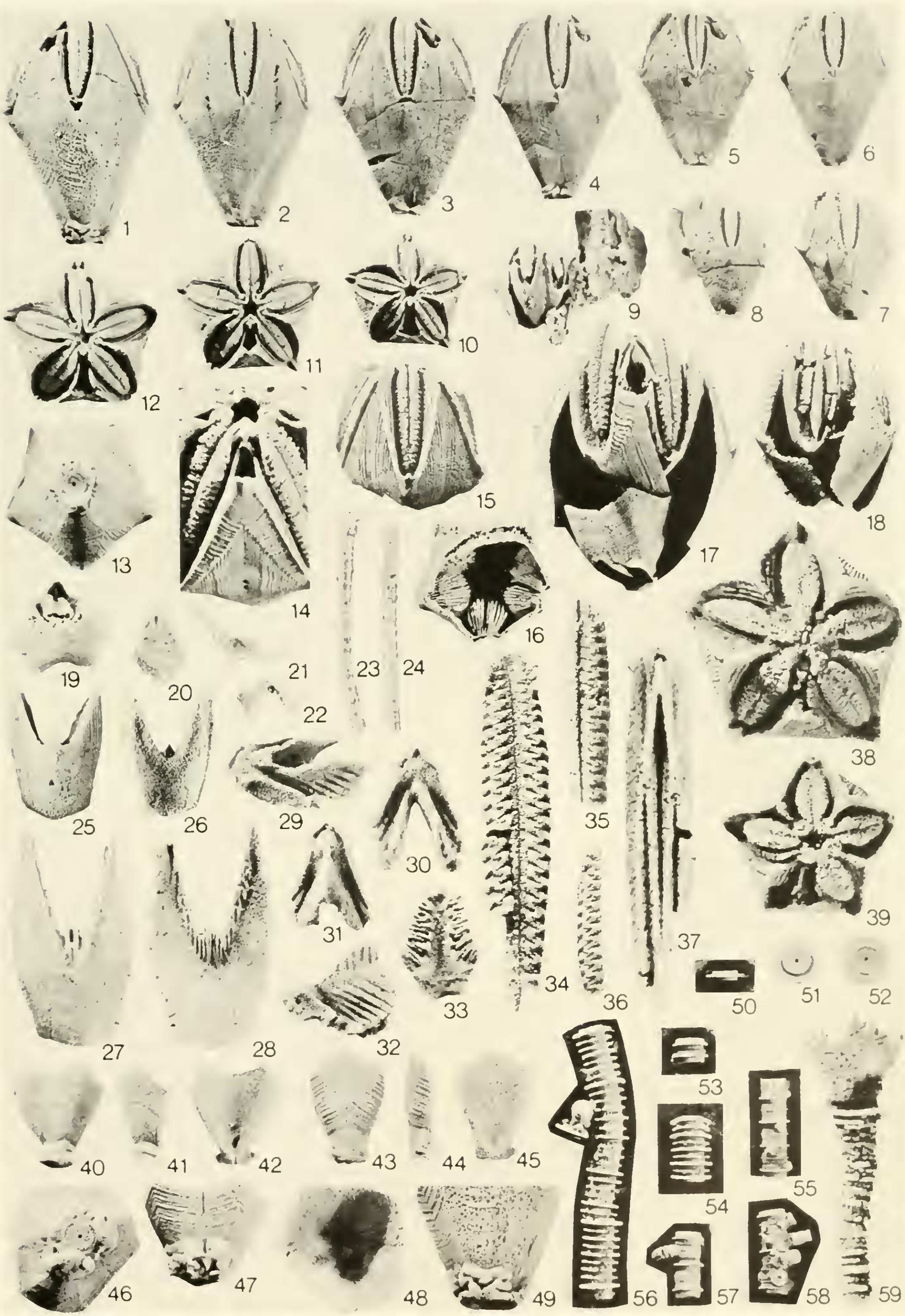
Of the three blastoid faunas now known from the Lodgepole and Allan Mountain Limestones in western Montana, only the lower fauna is sufficiently widespread and abundant to permit an analysis of its distribution pattern. Blastoids in the lower fauna have been collected at 31 of the 57 Lodgepole and Allan Mountain sections in western Montana studied by the authors during 1964–66 (Text-Fig. 1). A dividing line running through western Montana (see Text-Fig. 1) separates an area to the west and southwest where blastoids are consistently absent from a region to the east and northeast where blastoids are present at about 75% of the lower Lodgepole and Allan Mountain Limestone sections studied. This distribution trend appears to correspond to a lithologic change in the lower Lodgepole beds between 5 and 75 ft (1.5–23 m) where the lower blastoid fauna occurs. Three major factors are necessary in order for blastoids to be found at any given section: (1) good exposure, (2) the presence of a normal lower Lodgepole fauna, and (3) the occurrence of chert with corresponding silicification of the fossils. Good exposures of the lower Madison are present at many localities in western Montana, both east and west of this dividing line, so that exposure is generally not a factor. The characteristic fauna typically found in association with the blastoids disappears toward the west, probably because of a gradual facies change in the lower Lodgepole beds. The amount of chert present in these beds and the corresponding degree of silicification of the fauna also diminishes to the west, and again appears to be controlled by the source and amount of silica present. The disappearance of both the fauna and silicification are probably the result of increasing water depth to the west.

In the eastern part of the area, the beds between 5 and 75 ft (1.5–23 m) are composed of massive-bedded, fine-grained, micritic limestones that are cherty and contain an abundant silicified fauna, including common blastoids, especially in the lower part of the section. To the west, the upper boundary of these fossiliferous, cherty beds appears to gradually migrate down-section, and they are replaced by rhythmically interbedded, dark, micritic limestones and lighter dolomitic shales lacking both fossils and chert. Near the boundary line between the two areas, the chert and then the fossils (including the blastoids) are lost from the lower part of the section. West of the dividing line, these rhythmically banded limestone-shale alternations begin at the top of the resistant basal ledge in the Paine Member only 3 to 5 ft (0.9–1.5 m) above the base, and fossils and chert are absent above this level. The cherty, fossiliferous beds to the east apparently represent upramp, shallow-water deposition, in contrast to the rhythmic, parallel-interbedded dark limestones and dolomitic shales devoid of fossils and chert to the west that appear to represent deeper water deposition well below wave base (Text-Fig. 10). Apparently subsidence was more rapid in the western part of the area above the basal Paine unit than to the east where the shallow-water blastoids and other fossils commonly occur.

→

PLATE 2

Figures 1–59. *Koryschisma elegans* Sprinkle and Gutschick, n. gen., n. sp., upper Paine Member, middle Lodgepole Limestone, Bandbox Mountain, northern Little Belt Mountains, west-central Montana. 1, 12–13, 49, C-side, top, bottom, and enlarged basal deposits of holotype MCZ 915 showing large size, missing hypodeltoid, medium growth lines, and very large secondary deposits at stem facet, ×2 and ×3(49); 2, 11, 14, C-side, top, and enlarged oblique summit views of large paratype MCZ 916; note growth lines and raised hypodeltoid still in place, ×2 and ×4(14); 3, D-side view of large paratype MCZ 917 showing several cracks through theca, ×2; 4, D-side view of medium paratype MCZ 918; note fine growth lines and missing hypodeltoid, ×2; 5, 10, D-side and top views of medium paratype MCZ 919 showing lower L/W ratio than 6, missing hypodeltoid, and large lips at RR origins, ×2; 6, A-side view of medium paratype MCZ 920; note elongate shape and fine growth lines, ×2; 7, C-side view of medium paratype MCZ 921 with tip of BB broken off, ×2; 8, B-side view of small paratype MCZ 922 stuck to a radial plate, ×2; 9, C-side view of small paratype MCZ 923 which is partly disarticulated and stuck to a piece of silicified matrix, ×2; 15–16, E-side and bottom views of broken paratype MCZ 924 showing relatively coarse growth lines, hydrospire slits in ambulacral sinus wall, and well-preserved hydrospires in thecal cavity, ×2.5 and ×2; 17, CD-side view of large crushed paratype MCZ 928; note one-piece epideltoid and development of growth lines on D radial, ×3; 18, side view of medium paratype MCZ 927 showing side plates lying beside partly-exposed lancet, ×3; 19, broken radial plate with ambulacrum (paratype MCZ 956); note large radial lip, cross-sectional shape of ambulacrum, and trace of hydrospires, ×3; 20–22, exterior, left edge, and adoral views of three hypodeltoids (paratypes MCZ 952, 951, and 953) showing adoral projection and faint growth lines, ×6; 23–24, two brachiole segments (paratypes MCZ 958 and 959); note brachiolar plates and trace of cover plates (at left), ×6; 25–26, small paratype radial MCZ 954 showing shape and plate thickness, ×6; 27–28, large paratype radial MCZ 957; note growth lines, much longer ambulacral sinus, and trace of hydrospire folds on interior, ×3; 29–30, oblique edge and exterior views of paratype epideltoids MCZ 950 and 949 showing limbs infolded into hydrospires and right limb extending higher on plate than left limb, ×6; 31–33, exterior, edge, and aboral views of paratype deltoids MCZ 948, 946, and 947; note serrated crest, curved RD suture, and numerous hydrospire folds, ×6; 34, 37, exterior and interior of nearly complete paratype ambulacrum MCZ 942 showing lancet exposure, side plates with lateral spines adorally, and deep groove beneath lancet, ×6; 35, partial ambulacrum (paratype MCZ 944) with exposed lancet and right set of side plates, ×6; 36, partial side plate set (paratype MCZ 945) from left side of ambulacrum, ×6; 38, top view of paratype theca UMMP 60694 (Macurda Collection, no. 16 in growth series) showing tiny oral cover plates in place over mouth and adoral ambulacra, ×4; 39, top view of abnormal paratype theca UMMP 60688 (Macurda Collection, no. 10 in growth series); note two ambulacra combined together in E ray and no ambulacrum (or food groove) in D ray, ×3; 40–42, exterior, edge, and interior views of paratype BD basal MCZ 940 showing shape, growth lines, and oblique depression just above stem facet (42), ×3; 43–45, exterior, edge, and interior views of paratype azygous AB basal MCZ 941; note narrower shape and slightly coarser growth lines, ×3; 46–48, aboral, side, and adoral views of large paratype basal set MCZ 939 showing shape, growth lines, and very heavy secondary deposits forming stem facet, ×3; 50, side view of single paratype columnal MCZ 936 with flange, ×2; 51–52, top views of two paratype columnals MCZ 934 and 935; note central lumen, tiny crenulae, and different-sized flanges, ×2; 53, side view of two flanged columnals (paratype MCZ 937), ×2; 54, side view of short proximal stem segment (paratype MCZ 930) showing closely-spaced alternating columnals, ×2; 55, side view of distal stem segment (paratype MCZ 933); note widely-spaced alternating columnals and cirri branching off between flanges, ×2; 56, side view of longest preserved stem segment (paratype MCZ 931) showing alternation of columnal types in proximal stem, ×2; 57, side view of distal stem segment (paratype MCZ 932); note somewhat overgrown columnals and one large cirrus, ×2; 58, side view of distalmost stem segment (paratype MCZ 938) with numerous cirri or rootlets branching off mostly from right side, ×2; 59, side view of very small basal set and attached proximal stem (paratype MCZ 961), ×6.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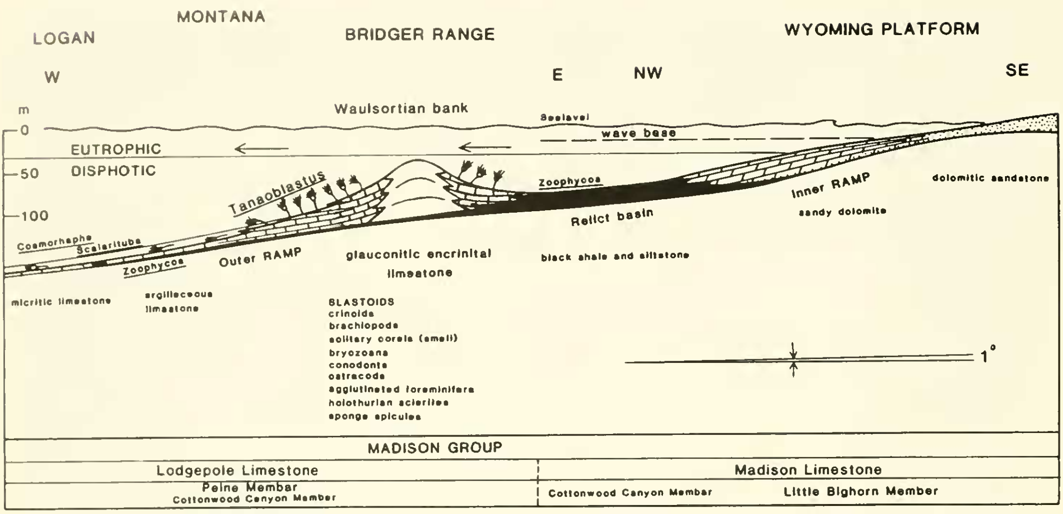


Text-Figure 10. Transect across western Montana showing the paleoecologic setting for the lower Lodgepole blastoid fauna during the *Siphonodella crenulata* Zone. Although they were uncommon and widely spaced in the outer ramp, a Waulsortian bioherm is shown in this cross section growing upward toward the surface with blastoids living on its flanks (after Sandberg and Gutschick, 1983).

In the eastern part of the area where blastoids are relatively abundant, the small globular genus *Tanaoblastus* is clearly dominant in the lower Lodgepole and Allan Mountain blastoid fauna. It is present at nearly every lower Lodgepole and Allan Mountain section where blastoids have been found. At most sections, *Tanaoblastus* is either the only form present or the dominant form, and is represented by a total of 1,109 specimens or about 88% of all the blastoids collected. Elongate ellipsoidal specimens of *Strongyloblastus*, conical and biconical specimens of the fissiculate *Orophocrinus*, plus biconical specimens of *Metablastus* also occur in this lower zone fauna, but are much less common and more restricted in their distribution. Specimens of these other genera are most common at a few sections in the central part of the study area in southwestern Montana (see Text-Fig. 8), primarily Dry Hollow, Milligan Canyon, Milligan Canyon East, and South Boulder. Several other Early or Middle Mississippian blastoid faunas, such as those from the Tournaisian of Belgium (Macurda, 1967), the Lake Valley Limestone of New Mexico (Fay, 1962c), and the Chouteau Limestone of Missouri and Iowa (Peck, 1938), are also dominated by a small globular spiraculate blastoid, whereas other conical, biconical, or ellipsoidal blastoid genera are less common (see Table 2).

AGE OF THE BLASTOID FAUNAS

The age and zonation of the Lodgepole Limestone, including the intervals containing the blastoid faunas, were discussed in Gutschick, Sandberg, and Sando (1980); Sandberg *et al.* (1983, pp. 707–711); and Sando and Bamber (1985). The lower Lodgepole blastoid fauna occurs in the basal 75 ft (23 m) of the Paine Member which was deposited about 4.5 to 6 million years after the Devonian-Mississippian boundary (middle Kinderhookian, early Tournaisian) using the time scale of Palmer (1983). This unit was deposited during the time interval of the Lower *Siphonodella crenulata* conodont zone, Pre-7 foram zone (Sando, Mamet, and Dutro, 1969), and IB coral zone (Sando and Bamber, 1985). The blastoids in the lower fauna (Table 2) correlate best with those in the

TABLE 2. COMPARISON OF THE LOWER LODGEPOLE AND ALLAN MOUNTAIN BLASTOID FAUNA IN MONTANA WITH OTHER EARLY AND MIDDLE MISSISSIPPIAN BLASTOID FAUNAS FROM WESTERN CANADA, NEW MEXICO, MISSOURI (2 UNITS), AND BELGIUM. NOTE THAT ALL OF THESE FAUNAS HAVE A SMALL GLOBULAR, SPIRACULATE BLASTOID, USUALLY AS THE DOMINANT FORM.

Fauna	Small globular spiraculate	Large ellipsoidal spiraculate	Biconical spiraculate	Conical fissiculate	Other fissiculates
Lower Lodgepole and Allan Mountain Lmst., Montana (this study)	*Tanaoblastus* 1109	*Strongyloblastus* 48	*Metablastus* 6	*Orophocrinus* 46	—
Banff Formation, Alberta & British Col. (Fritz & Cline, 1937)	*Cryptoblastus*	*Strongyloblastus*	—	—	—
Lake Valley Limestone, New Mexico (Fay, 1962c)	*Monadoblastus*	—	—	*Phaenoschisma*	*Hadroblastus*, *Koryschisma*
Chouteau Formation, Missouri (Peck, 1938; Macurda, 1964)	*Tanaoblastus*	—	—	*Phaenoschisma*	*Hadroblastus*
Lower Burlington Limestone, Missouri (Sprinkle, pers. coll.)	*Globoblastus*, *Poroblastus*	"*Pentremites*"	*Dentiblastus*	*Phaenoschisma*	*Orophocrinus*, *Hadroblastus*
Tournaisian of Tournai, Belgium (Macurda, 1967)	*Mesoblastus* 200	—	—	*Orophocrinus*, *Katoblastus* 6 & 10	*Phaenoblastus*, *Katoblastus* 100 & 10

Chouteau Limestone of Missouri (see Peck, 1938) and those of the type-Tournaisian of Belgium (see Macurda, 1967). The middle Lodgepole blastoid fauna occurs between 110 and 200 ft (34–61 m) up in the Paine Member which dates about 6 to 7.5 million years after the Devonian-Mississippian boundary (late Kinderhookian, early Tournaisian) during the time interval of the *Siphonodella isosticha*–upper *S. crenulata* conodont zone, Pre-7 foram zone, and IC coral zone (Sandberg *et al.*, 1983). The middle Lodgepole blastoid fauna with its two new genera does not correlate well with blastoid faunas in other areas. The upper Lodgepole blastoid fauna occurs in the top 200 ft (61 m) of the overlying Woodhurst Member which was deposited 9–10 million years after the Devonian-Mississippian boundary (early Osagean, middle Tournaisian) during the time interval of the Lower *Gnathodus typicus* conodont zone, foram zone 7, and lower IIB coral zone (Sandberg *et al.*, 1983). The three blastoids in the upper Lodgepole fauna resemble those in the Osagean lower Burlington Limestone in Missouri.

PALEOGEOGRAPHY AND PALEOECOLOGY

A generalized regional paleogeographic pattern has evolved for the Early Mississippian history of western Montana (Holland, 1952; Wilson, 1969; Rose, 1976; Sando, 1976; Haines, 1977; Smith, 1977, 1982; Roberts, 1979; Gutschick, Sandberg, and Sando, 1980; Lane, 1982; Gutschick and Sandberg, 1983) that can provide the environmental setting for Lodgepole blastoids of this study (Text-Figs. 1 and 10). Montana in Early Mississippian time was a broad carbonate marine shelf covered by the Madison Sea. An east-west unstable Central Montana Trough (Big Snowy and Crazy Mountains Troughs) separated two stable platforms, the Wyoming Shelf to the southeast and the Alberta Shelf to the northeast on the boundary with Saskatchewan and Alberta (Wilson, 1969; Smith, 1982). Broad, gently sloping, carbonate ramps of the drowned homoclinal type (Read, 1985) extended from the platforms into deeper water of the Central Montana Trough and westward towards the north-south miogeosyncline in western Montana (Text-Fig. 10). Drowning was in large part caused by sea level changes, including a major regression at the Devonian-Mississippian boundary, followed by a major transgression during Lodgepole deposition (*S. crenulata* and *G. typicus* conodont zones). Rhythms (cycles) of sedimentation in the Lodgepole and Allan Mountain Limestones (Wilson, 1969; Smith, 1972; Haines, 1977) may reflect minor transgressive-regressive fluctuations and subsidence.

Waulsortian-facies carbonate mounds (Text-Fig. 10) have been recognized downramp at Swimming Woman Canyon in the Big Snowy Mountains (Cotter, 1965, 1966), in the Bridger Range (Stone, 1972; see Text-Fig. 4), at Belt Creek Canyon (Wilson, 1969) and at Bandbox Mountain (Sandberg and Klapper, 1967; see Text-Fig. 5) in the Little Belt Mountains, and at Lone Butte and Crown Mountain (Haines, 1977; see Text-Fig. 6) in the Lewis and Clark Range. The best paleolatitudinal position of Montana during the Early Carboniferous from paleomagnetic data is approximately 5° North (C. R. Scotese, personal communication 7/18/86). This places the carbonate setting of our blastoid localities in the tropical realm just north of the paleoequator. The resulting wind pattern may have produced some upwelling towards the Wyoming Shelf. However, Van der Voo (1988) places the Late Devonian paleoequator just north of the Montana study area, so that it would be in the southern hemisphere tropics.

A transect depicting the paleoecological setting for the Early Mississippian blastoids of this study is presented in Text-Figure 10, extending from the Wyoming Shelf through the Bridger Range and westward beyond Logan, Montana, towards the Antler Flysch Trough (Mamet, 1972; Armstrong and Mamet, 1977; Sandberg and Gutschick, 1983). The lower Lodgepole and Allan Mountain blastoid faunas occur with a diverse assemblage of marine invertebrates representing an outer shelf environment on a carbonate ramp below normal wave base. Generalized faunal lists for the intervals yielding the lower and middle Lodgepole blastoid faunas are presented in Table 3.

Several faunal groups have been extensively studied, including the agglutinated foraminifera (Gutschick, Weiner, and Young, 1961; Gutschick, 1964, fig. 5; Sandberg and Gutschick, 1984), corals (Sando and Bamber, 1985), brachiopods (Rodriguez and Gutschick, 1968, 1969), crinoids (Laudon and Severson, 1953), holothurian sclerites (Gutschick, Canis, and Brill, 1967), goniatites (Gordon, 1986), conodonts (Klapper, 1966; Sandberg and Gutschick, 1983), and trace fossils (Rodriguez and Gutschick, 1970).

Taphonomic observations were made from silicified blastoids collected from bedding surfaces and blocks in the lower blastoid fauna; thanatocoenoses were extracted from acid residues and studied on bedding slab surfaces in the middle blastoid fauna. Blastoids most commonly occur with crinoids (especially disarticulated stems and plates), fenestellid bryozoans, and small brachiopods. Blastoids are rarely found in beds containing abundant corals but do occur with occasional small solitary corals and recumbent branching aulopotids.

The Lodgepole blastoids were probably medium-level rheophilic suspension feeders. Most blastoid thecae are fairly small (5–20 mm long), and even the most complete preserved stem is only 29 mm long, although the original length may have been several times this figure. This would put these blastoids in the middle tier of suspension feeders below the top canopy of long-stemmed crinoids but above low-level epifaunal forms such as the fenestellid bryozoans and brachiopods (Ausich and Bottjer, 1985).

It is unusual to find complete blastoid specimens with appendages intact. Only two localities with Lodgepole blastoids out of 37 had complete blastoids with appendages. This suggests that most blastoids were not buried instantly at the time of death or distal detachment but lay exposed on the seafloor after death for several days or weeks before being buried, thus allowing the delicate appendages to become dissociated (Sprinkle and Gutschick, 1967). Many specimens were subsequently crushed during diagenesis, probably because they were filled with soft sediment susceptible to compaction. Only a few blastoid thecae show any evidence of post-mortem disturbance by burrowers (see Plate 4, Fig. 26).

Blastoids were not found by us within any of the Waulsortian bioherms in the Lodgepole. Blastoids were found at two localities in beds below and adjacent to Waulsortian bioherms, and they are shown living on the flanks of these mounds in our paleoecological diagram (Text-Fig. 10). *Tanaoblastus* from the lower fauna occurs just below and in flank beds adjacent to a small white bioherm in the lower Paine Member at the Bridger Mountain Section (BG) in the southern Bridger Range. At Bandbox Mountain in the northern Little Belt Mountains, the middle blastoid fauna occurs in black, thick-bedded limestones about 10 ft (3 m) below the base of a large white bioherm or bank (see Text-Fig. 5).

The lack of complete articulated fossil animals within the Waulsortian mound core, e.g., stalked crinoids or blastoids, should not seem unusual. The mound structure on the inclined ramp has relatively steep flanks, ranging from 5° to 29° (Cotter, 1965; Smith, 1982) to as much as 40° (Laudon and Bowsher, 1941). Globular calyces can easily be transported by gravity and traction currents out and away from the bioherms. In the case of Mississippian crinoids associated with Waulsortian bioherms in the Sacramento Mountains, New Mexico, large numbers of calyces (prolific Lake Valley crinoid fauna) accumulated downslope as scree on the leeward side flank of the bioherms in a geopetal fashion (Laudon and Bowsher, 1941, 1949, personal communication).

Agglutinated foraminifera, particularly the abundance of elongated tubular hyperamminids in the Lodgepole, inhabited the outer shelf and slope environment (Sandberg and Gutschick, 1984); small solitary corals of genera typical of the lower Lodgepole are deeper-water types (Sando, 1980; Gutschick and Sandberg, 1983, fig. 7C; Sando and Bamber, 1985). Species of the conodont *Siphonodella* are associated with offshore deeper-water environments (pelagic nekton) (Dreesen, Sandberg, and Ziegler, 1986), and the trace fossils *Scalarituba* and *Cosmorhaphe* inhabit the slope in offshore deeper water (Gutschick and Sandberg, 1983, fig. 7F). Fenestellid bryozoans (Cuffey, 1985), brachiopods, and the conspicuous lack of calcareous algae in the blastoid facies are compatible with this general environmental pattern.

SYSTEMATIC PALEONTOLOGY

Class BLASTOIDEA Say, 1825
Order FISSICULATA Jaekel, 1918
Family PHAENOSCHISMATIDAE Etheridge and Carpenter, 1886
Genus KORYSCHISMA Sprinkle and Gutschick, new genus

Type Species. Koryschisma elegans Sprinkle and Gutschick, new species.

Diagnosis. Fissiculate blastoids with an obconical theca, pelvis longer than vault, radials and deltoids raised into crests above ambulacra; 10 partly exposed hydrospire fields, 3–9 hydrospire slits per field (number increasing with size), number of slits slightly reduced on anal side; two anal deltoids, epideltoid with long aboral limbs,

TABLE 3. LISTS OF FOSSILS FOUND IN THE LOWER LODGEPOLE BLASTOID FAUNA 5–75 FT (1.5–23 M) ABOVE THE BASE OF THE LODGEPOLE AND ALLAN MOUNTAIN LIMESTONES AND IN THE MIDDLE LODGEPOLE BLASTOID FAUNA 110–200 FT (34–61 M) ABOVE THE BASE OF THE LODGEPOLE LIMESTONE IN WESTERN MONTANA. LOWER FAUNA BASED PARTLY ON A FIELD CENSUS TAKEN FROM TALUS BLOCKS AT STANDARD CREEK IN 1966; MIDDLE FAUNA BASED PARTLY ON ACID RESIDUES FROM BANDBOX MOUNTAIN (IDENTIFIED BY FRANCIS ZIMMER) AND ANT PARK, AND A CENSUS OF SLAB SURFACES COLLECTED FROM NORTHEAST BALDY MOUNTAIN →

Fossil group	Lower blastoid fauna	Middle blastoid fauna
Protozoa		
Foraminiferida		
Textulariina	*Hyperammina rockfordensis*	*Hyperammina rockfordensis-H. kentuckyensis* transit.
	Pseudastrorhiza digitata	—
	P. 2 species	—
	Trepeilopsis glomospiroides	—
	Ammobaculites leptos	—
	—	*Rheophax calathus*
	—	*R. raymoorei*
	—	*Tolypammina* sp.
Fusulinina	*Septglomospiranella* sp.	—
	Septabrunsiina sp.	—
	Latiendothyra sp.	—
	—	*Chernyshinella* sp.
	—	*Paleospiroplectammina* sp.
	—	*Rectoseptaglomospiranella* sp.
Porifera	Siliceous spicules	Siliceous spicules
	—	Globular form with spicules
Coelenterata		
Anthozoa		
Rugosa	*Amplexus* sp.	*Amplexus* sp.
	Amplexizaphrentis sp.	*Amplexizaphrentis* sp.
	Amplexocarinia sp.	*Amplexocarinia* sp.
	Cyathaxonia tantilla	*Cyathaxonia tantilla*
	Cleistopora placenta	—
	Metriophyllum deminutivum	—
	Neaxon? sp.	—
	Palaeacis sp.	—
	—	*Sychnoelasma subcrassum*
	—	*Stelechophyllum microstylum*?
Tabulata	*Aulopora* sp.	*Aulopora* sp.
	Cladochonus sp.	—
	—	*Syringopora* sp.
Bryozoa		
Cystoporata	—	*Cystodictya* sp.
	—	*Fistulipora* sp.
	—	*Sulcoretepora*? sp.
	—	Unidentified Cystodictyonid
Cryptostomata	—	*Nicklesopora* sp.
	—	*Rhombopora* or *Rhabdomeson* sp.
Fenestrata	Several Fenestellids	6 genera of Fenestellids
	—	*Hemitrypa* sp.
	—	*Penniretepora* sp.
	—	*Ptylopora* sp.
	—	Unidentified Acanthocladid
	—	*Septopora* sp.

(*continued*) IN 1966 AND 1984–85. PUBLISHED SOURCES FOR INFORMATION ON PARTICULAR GROUPS LISTED BELOW INCLUDE: GUTSCHICK (1964), GUTSCHICK, WEINER, AND YOUNG (1961), AND MAMET AND SKIPP (1970), FORAMS; SANDO (1983) AND SANDO AND BAMBER (1985), CORALS; MCKINNEY (PERSONAL COMMUNICATION, 1987), MIDDLE FAUNA BRYOZOANS; RODRIGUEZ AND GUTSCHICK (1968, 1969), LOWER FAUNA BRACHIOPODS; GORDON (1986), LOWER FAUNA AMMONOIDS; RODRIGUEZ AND GUTSCHICK (1970), TRACE FOSSILS; LAUDON AND SEVERSON (1953), CRINOIDS; GUTSCHICK, CANIS, AND BRILL (1967), HOLOTHURIANS; AND SANDBERG *ET AL.* (1978), CONODONTS.

Fossil group	Lower blastoid fauna	Middle blastoid fauna
Brachiopoda		
Inarticulata	*Crania* sp. cf. *C. blairi*	—
Articulata		
Orthida	*Rhipidomella* sp.	—
Strophomenida	*Caenanoplia logani*?	*Caenanoplia logani*?
	—	*Buxtonia*? sp.
	Productina lodgepolensis	—
	Leptagonia analoga	*Leptagonia analoga*
Rhynchonellida	*Camarotoechia* sp.	*Camarotoechia metallica*
	—	*C. tuta*
	—	*C. inaequa*?
	Axiodeaneia platypleura	—
Spiriferida	*Cleiothyridina* sp.	*Cleiothyridina obmaxima*
	—	*C. glenparkensis*
	—	*C.* sp. cf. *C. incrassata*
	Crurithyris parva?	—
	Cyrtina burlingtonensis	—
	—	*Eumetria osagensis*?
	Hustedia texana	*Hustedia texana*
	Nucleospira obesa	—
	Plectospira? *problematica*	—
	—	*Prospira greenockensis*?
	—	*Punctospirifer solidirostris*
	—	*Reticularia cooperensis*?
	Spirifer sp.	*Spirifer missouriensis*
	—	*S. albapinensis*
Terebratulida	*Dielasma*? sp. cf. *D. utah*	*Dielasma* sp. cf. *D. utah*
Mollusca		
Gastropoda	*Platyceras* sp.	*Platyceras paralius*
	—	*P.* 3 sp.
	—	*Goniospira* sp.
	—	*Bellerophon* sp.
	Several other genera	At least 8 other genera
Bivalvia	—	*Palaeoneilo missouriensis*
	—	*Allorisma*? sp.
	—	*Leptodesma* sp.
	Unidentified small bivalves	—
Cephalopoda		
Nautiloidea	*Triboloceras digonum*	—
	—	1 orthoconic genus
Ammonoidea	*Imitoceras* sp.	1 or more goniatites
	Gattendorfia costata	—
	Pericyclus rockymontanus	—
	Rotopericyclus sp.	—
"Worms"	—	*Spirorbis nodulosus*
	Spirorbis sp.	*S.* sp.
	—	*Tentaculites* sp.

Table 3. Continued.

Fossil group	Lower blastoid fauna	Middle blastoid fauna
Trace Fossils	*Cosmorhaphe* sp.	*Cosmorhaphe* sp.
	Scalarituba missouriensis	*Scalarituba missouriensis*
	—	*Zoophycos* sp.
	Horizontal burrows	Horizontal burrows
Arthropoda		
Trilobita	—	*Richterella snakedenensis*?
Ostracoda	Several genera	Several genera
Echinodermata		
Crinoidea		
Inadunata	*Amphelecrinus madisonensis*	*Amphelecrinus madisonensis*
	Linocrinus walsallensis	—
	Unidentified microcrinoids	—
Camerata	*Abactinocrinus rossei*	—
	Actinocrinites sp.	—
	—	*Cactocrinus arnoldi*
	Platycrinites bozemanensis	*Platycrinites bozemanensis*
	—	*Rhodocrinites douglassi*
Blastoidea		
Fissiculata	*Orophocrinus macurdai*	—
	O. sp. cf. *O. gracilis*	—
	—	*Koryschisma elegans*
	—	*Hadroblastus* sp.
Spiraculata	*Tanaoblastus haynesi*	—
	T. allanensis	—
	—	*Cryptoblastus*? sp. B
	—	*C.*? sp. C
	Strongyloblastus breimeri	*Strongyloblastus laudoni*
	S. sp.	—
	—	*Montanablastus baldyensis*
	Metablastus milliganensis	—
Asteroidea	—	Starfish arm
Ophiuroidea	—	2 unidentified genera
Edrioasteroidea	—	2 specimens of 1 genus
Echinoidea	—	*Archaeocidaris aliquantula*
Holothuroidea	*Achistrum coloculum*	—
	A. gamma	—
	Eocaudina columcanthus	—
	E. subhexagona	—
	E. marginata	—
	Microantyx botoni	—
	M. mudgei	—
	Rota campbelli	—
	R. martini	—
Conodonta	*Siphonodella crenulata*	*Siphonodella crenulata*
	—	*Siphonodella isosticha*
	Several other genera & species from Lower *crenulata* Zone	Several other genera & species from Upper *crenulata-isosticha* Zone
Vertebrata		
Osteichthyes	—	Brachyodont crushing tooth
Totals	67+ Genera	83+ Genera

hypodeltoid, pointed or hooded, having wide growth front on thecal surface; regular deltoids fairly small, either barely appearing on thecal surface with tiny external DR growth sector, or confined to ambulacral sinuses, radials strongly overlap deltoids near thecal surface but overlap gradually reverses deeper into sinuses; ambulacra moderately long, linear to lanceolate, extending out from mouth in shallow sinuses or down theca in relatively deep sinuses, lancet slightly exposed, side plates usually conceal about two-thirds of slits in sinus walls; brachioles small, ridged on sides; stem made up of flanged columnals, cirri and rootlets present distally for attachment of stem to substrate using recumbent rhizoid holdfast.

Occurrence. Early Mississippian (Late Kinderhookian = Tournaisian) to latest Early Carboniferous (Late Visean and Early Namurian). Montana, New Mexico, Algeria.

Etymology. The generic name is derived from *korys, korystos* (Greek), crested, and *schisma* (Greek), slit, referring to the strongly raised deltoid crests bearing hydrospire slits in this genus.

Discussion. Koryschisma is represented by an excellent collection of silicified material from the middle Lodgepole Limestone at Bandbox Mountain in west-central Montana, including about 145 complete or partial thecae, several hundred separate plates and ambulacral fragments, several hundred stem segments and individual columnals, and even a few brachiole fragments. Quality of the silicification is generally very good, making it easy to study the morphology, and the numerous separate plates have yielded additional information about internal features.

Koryschisma differs from other Devonian and Mississippian phaenoschismatids by having medium to high deltoid crests, two anal deltoids with the hypodeltoid occurring on the thecal surface, and medium-length ambulacra with the lancet partly exposed. It most closely resembles *Leptoschisma* and *Pleuroschisma* from the Devonian and *Phaenoschisma* and *Hadroblastus* from the Mississippian. It appears to be intermediate between these Devonian and Mississippian genera, as noted by Breimer and Macurda (1972, p. 219, textfig. 104).

Koryschisma differs from *Leptoschisma* by having only two anal deltoids, larger deltoid crests with more hydrospire slits exposed, somewhat wider ambulacra with the lancet partly exposed, and no BA axis in the basals. *Koryschisma* differs from *Pleuroschisma* by having only two anal deltoids, wider and less depressed ambulacra that conceal more hydrospire slits and have the lancet partly exposed, usually lower deltoid crests with fewer hydrospire slits, and other minor differences. *Koryschisma* differs from *Phaenoschisma* by having a prominent hypodeltoid on the thecal surface, usually narrower ambulacra having less of the lancet exposed and covering fewer of the hydrospire slits, and (in the type species) regular deltoids that barely appear on the thecal surface. *Koryschisma* differs from *Hadroblastus* by having a more elongate thecal shape, higher deltoid crests with depressed ambulacra, less exposure of the lancet, usually fewer hydrospire slits, some of which are concealed, and other differences.

Breimer and Macurda (1972, pp. 18–20, 217–221) and Macurda (1983, pp. 60–65) described some of the morphologic and growth features of *Koryschisma elegans* (then unnamed), and informally assigned two other phaenoschismatid species to this genus. We agree with their assignments, and have briefly diagnosed and compared these other two species (*Koryschisma saharae* and *K. parvum*) with the type species described here in detail.

KORYSCHISMA ELEGANS Sprinkle and Gutschick, new species

Plate 2, Figures 1–59;
Text-Figures 9 and 11–12

"New Lower Mississippian genus from Montana; Phaenoschismatid n. gen.; 'undescribed phaenoschismatid B' (UB); Phaenoschismatid, new genus, new species. Miss., Lodgepole Fm., Bandbox Mountain, Cascade Co., Montana, USA.; undescribed phaenoschismatid genus; undescribed genus; 'X' . . . undescribed phaenoschismatid from Montana (UB); phaenoschismatid (UB) . . . from the Mississippian of Montana; phaenoschismatid UB," Breimer and Macurda, 1972, pp. 20, 219–221, 291–292, 312, 348, 362, and 366, textfigures 72, 100, and 104, table 2; Macurda, 1983, pp. 61–62 and 189, table 20.

Diagnosis. Theca large, obconical, L/W averages 1.39, pelvis somewhat longer than vault, V/P averages 0.67, pelvic angle averages 52°, crests moderately high with sharp raised edges, adoral edge of deltoids serrated, even with summit; ambulacra long, lanceolate, lancet about one-fourth of ambulacral width; 3–9 hydrospire slits per group, number slightly reduced on anal side; hypodeltoid prominent, hooded, other deltoids barely appearing on thecal surface, heavy secondary deposits at tip of basals; brachioles ridged; stem long with alternating flanged columnals, apparently attached distally using a recumbent rhizoid holdfast.

Description. About 145 partial and complete specimens plus about 500 separate plates, ambulacral pieces, stem segments and columnals, and brachiole segments available for study. Type specimens include holotype MCZ 915, 30 paratype thecae, including the 16-specimen growth series studied by Breimer and Macurda (1972), and 31 paratype fragments or plates.

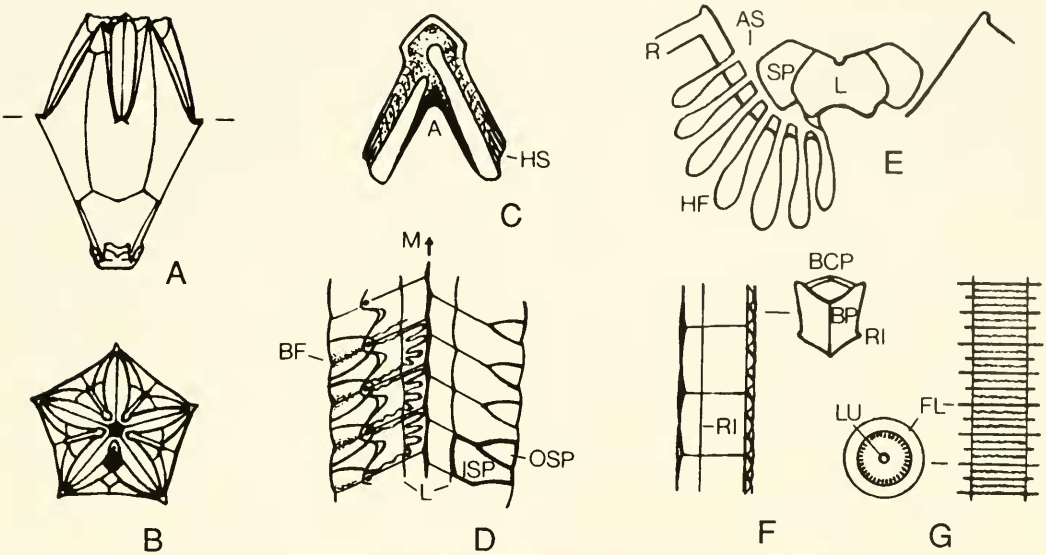
Theca obconical, pelvis longer than vault, maximum width at tips of ambulacra above midheight (Text-Fig. 11A), pelvis conical with nearly straight sides (basal profile very slightly convex, radial profile very slightly concave), stem facet relatively large with prominent secondary deposits, interambulacra nearly straight ignoring large radial lips, slightly concave with lips (Plate 2, Fig. 11). Holotype (largest theca in available collections; Plate 2, Figs. 1, 12–13) 19.0 mm long, 12.4 mm wide, with a vault 7.9 mm long and pelvis 11.2 mm long; smallest theca (Breimer and Macurda, 1972, textfig. 72.1) about 5.8 mm long and 4.8 mm wide. In eight complete MCZ thecae, L/W ratio ranges from 1.27 to 1.53 and averages 1.39, V/P ratio ranges from 0.48 to 0.80, averaging 0.67, and pelvic angle ranges from 42° to 58° and averages 52°. Summit nearly flat with sharp and fluted adoral deltoid edges.

Basals three, medium-sized forming about 40% of pelvis, normally arranged, two larger and one smaller (azygous), azygous basal elongate pentagonal, larger basals hexagonal; in large basal set (Plate 2, Figs. 46–48), azygous basal 5.7 mm long, 4.7 mm wide, larger basal about same length and 5.7 mm wide; stem facet formed by prominent secondary deposits bridging over triangular tip of basals to form large, nearly circular platform bearing stem facet with small central lumen. Oblique deep depression about 0.8–1.0 mm long near middle (C ray) of BD basal about 1.0 mm from stem lumen (Plate 2, Fig. 42), apparent site of internal organ near thecal base.

Radials five, large, forming most of thecal surface and 60% of pelvis, RD axis greater than RB axis at all sizes; each radial roughly rectangular with deep ambulacral sinus in adoral end, sides convex, profile convex with large radial lip at origin continuing pelvis profile; each ambulacrum strongly depressed below edge of radial sinus, which has sharp raised ridge about 1 mm higher than plate surface (Plate 2, Figs. 14–15).

Regular deltoids four, small, crested, barely reaching thecal surface (tiny V-shaped external DR growth sector just aboral to end of crest), crests horizontal on summit with wavy, serrated, or "cockscomb" edge, forming incipient paired spiracles adorally behind small deltoid lip (Plate 2, Fig. 11), small spine often on lip between spiracles, mouth rounded pentagonal, about 1.2 mm in diameter in large specimen, radials strongly overlap deltoids at top of sinus but overlap slightly reversed at and below edges of ambulacra (Plate 2, Fig. 32).

Anal deltoids two, medium-sized epideltoid with long depressed limbs and small diamond-shaped hypodeltoid on thecal surface. Epideltoid inverted V-shaped, lip



Text-Figure 11. Morphology of *Koryschisma elegans*, n. gen., n. sp. A–B, side and summit views of a large theca based on holotype MCZ 915 and paratype MCZ 916 showing greatest width (short lines) above midheight, enlarged hypodeltoid appearing on thecal surface, and heavy secondary deposits forming stem facet. C, much-enlarged epideltoid based mostly on paratype MCZ 949; note location of anus (A), adoral ends of hydrospire slits (HS) on limbs, and ridge on right limb extending further adoral than left limb. D, enlarged view of ambulacrum in paratype MCZ 942 showing central lancet (L) and inner and outer side plates (ISP and OSP) bearing brachiole facets (BF) at the edge; small arrow points toward mouth (M). E, enlarged cross section of ambulacrum and adjacent radial (R) drawn mostly from paratypes MCZ 956, MCZ 942 (inside of ambulacrum), and MCZ 924 (hydrospires); note side plates (SP) wrapping around edge of central ridged lancet (L) with slits in the ambulacral sinus (AS) leading to internal hydrospire folds (HF). F, much-enlarged side view and cross section of isolated brachiole fragment MCZ 959 showing ridge (RI) on biserial brachiolar plates (BP) and tiny brachiolar cover plates (BCP). G, much-enlarged side view and columnal face of proximal stem segment MCZ 931; note equatorial flange (FL) on alternating columnals and smaller central lumen (LU).

slightly wider than other deltoid lips, limbs infolded into hydrospires with folds extending from limbs into space for hindgut, adorally ridge from "C" limb slightly higher than that for "D" limb (Text-Fig. 11C; Plate 2, Figs. 17, 30). Hypodeltoid greatly enlarged over other deltoid bodies with large external HDR sector, slightly to moderately hooded, adoral edge projecting slightly above other deltoid crests and summit (Plate 2, Figs. 14, 21), forms aboral side of elliptical anus slightly larger than mouth (1.8 mm long in 18 mm long theca), forms strongly convex sutures with radials, grows aborally from near tip of hood.

Ambulacra five, relatively long, moderately wide, lanceolate, moderately convex in cross section, slightly curved in profile, lancet slightly exposed in center, one-third to one-half of its width and one-fourth of ambulacral width, side plates curve around lateral edges of lancet (Text-Fig. 11E; Plate 2, Figs. 18, 34, 37), lancet grooved at bottom with adoral keel, inner side plates large, constricted abmedially, outer side plates small, rounded triangular, notch abmedial aboral edge of inner side plate, inner and outer side plates form brachiole facet at abmedial edge of ambulacrum, brachiolar pit small, at end of side food groove on side plate suture (Text-Fig. 11D), brachiolar facets together hemielliptical, about 0.25 mm long, canted toward each other so that deepest part between them on side plate suture. Side food grooves enter main food groove at 45–70° angle, four lobes per side plate along main food groove, 3–5 adorally and two small lobes aborally along side food grove.

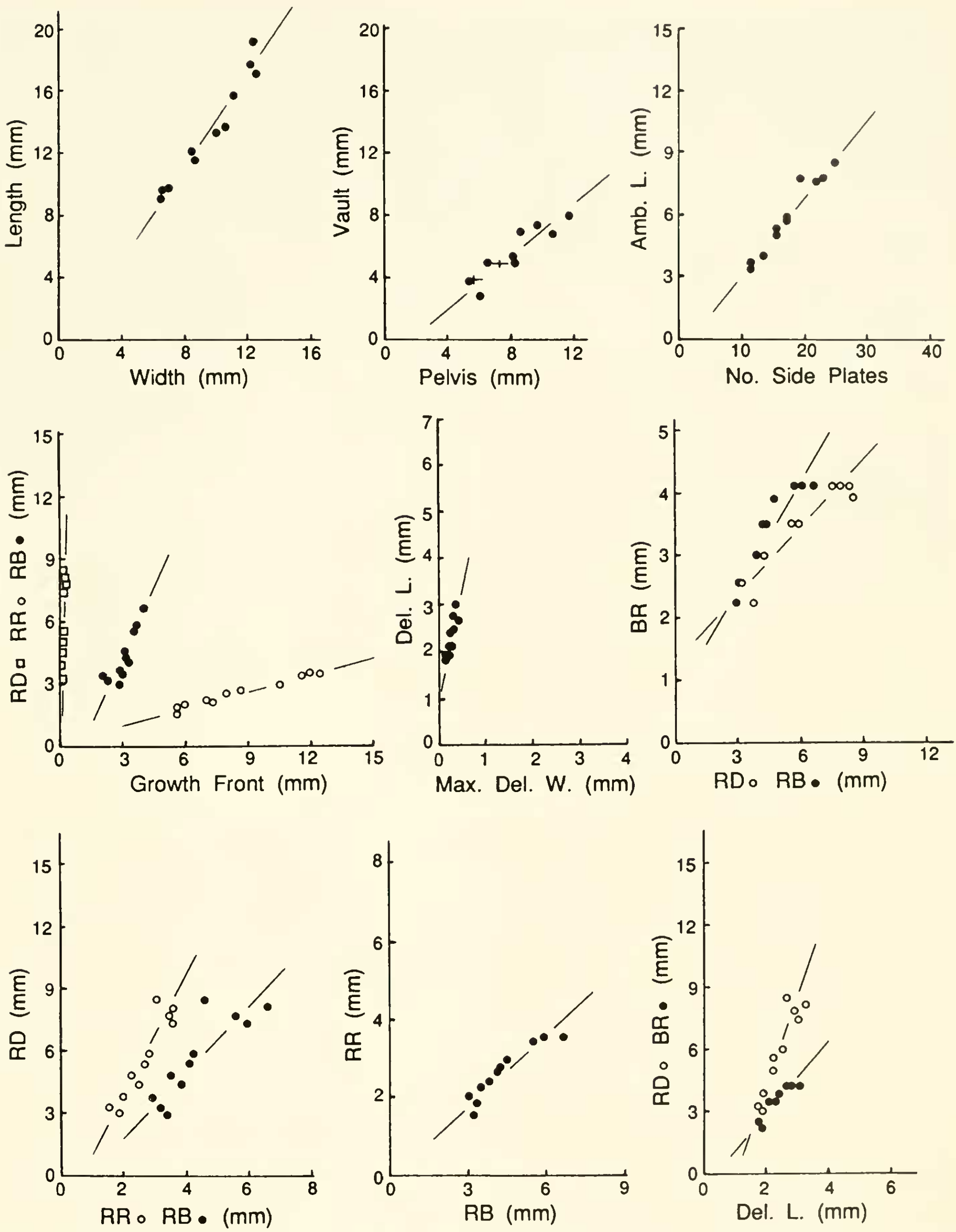
Oral cover plates present on summit of one paratype (UMMP 60694; Plate 2, Fig. 38), form five domed covers about 0.4 mm high and 0.6 mm wide made up of tiny plates about 0.15 mm in size over adoral ambulacra converging at mouth. Symmetry appears pentagonal over mouth with no apparent "2-1-2" arrangement in covers. Several paratypes (especially UMMP 65893) show remnants of small spines about 0.6 mm long and 0.15 mm in diameter near mouth and anus (Plate 2, Fig. 38), apparently to protect these summit structures.

Hydrospires in 10 groups, slits partly exposed in sinus and crest walls, mostly hidden beneath ambulacra, 3–9 folds per normal group, number slightly reduced on anal side to 2–7 folds; lower folds hang down into thecal cavity, deepest at radiodeltoid suture (Plate 2, Figs. 16, 33), upper folds extend laterally in from sinus edges, short slit and fold at top of sinus (Plate 2, Fig. 15) probably added late in growth; in internal view folds bend abmedially at radiodeltoid suture, folds pinched together at aboral end near radial origin (Plate 2, Fig. 16); adoral edges of ambulacra form incipient spiracles at adoral edge of deltoid crests.

Ornament consists of fine to medium-strength growth lines parallel to margins on basals and radials, stronger growth lines on RHD front (Plate 2, Figs. 15, 17), very fine growth lines on hypodeltoid and sides of deltoids. Several heavy layers of secondary deposits over origins of basals to produce large circular platform for stem attachment from smaller triangular tip of basal cone (Plate 2, Figs. 40–42, 46–47, and 49); secondary deposits also forming large, pointed, radial lip up to 1.5 mm long that continues pelvic profile, lip covers few growth lines at origin of each radial, and bears median raised ridge adorally to separate brachiole groups (Plate 2, Figs. 12, 17). Thin 1 mm high ridge of secondary calcite along edge of each ambulacral sinus above plate surface (Plate 2, Figs. 15, 27); several lateral-pointing spines of apparent secondary calcite on adoral-most side plates (Plate 2, Fig. 34); and small spine of secondary calcite on some deltoid and epideltoid lips.

Disarticulated stem material abundant (Text-Fig. 9); distinctively flanged and somewhat heteromorphic proximally, developing cirri and rootlets distally. Longest stem segment 22 mm long with 33 columnals (Plate 2, Fig. 56); one short stem segment attached to small basal set (Plate 2, Fig. 59); one theca had single columnal attached but lost it during etching. Proximal columnals thin, wide, with a large flange (Plate 2, Figs. 52, 54, and 56); typical proximal columnal 0.4 mm long, 1.6 mm wide, having a circular equatorial flange 2.5–3.0 mm in diameter; columnal faces round with 49–50 small crenulae around margin and small, nearly circular lumen 0.1 mm in size in center (Text-Fig. 11G). Two or three sizes of flanged columnals alternating in proximal stem, either in sequence "lg.-sm.-med.-sm., lg.-sm.-med.-sm., . . ." or as "lg.-sm., lg.-sm., . . ." (Plate 2, Figs. 54, 56). Distal columnals longer (0.5–0.7 mm long), narrower (1.2–1.3 mm wide), with smaller flanges (1.3–1.5 mm in diameter) that alternate somewhat in size and appear partly covered by subsequent lateral growth of columnals (Plate 2, Fig. 55). Cirri (rootlets?) attached to distal columnals on flanges or sutures (Plate 2, Fig. 58), most cirrals about 0.25 mm long, 0.5–0.8 mm in diameter, with faces bearing 11–14 small crenulae. Cirri apparently concentrated on one side of best distal stem segment (Plate 2, Fig. 58), implying a recumbent rhizoid holdfast (Brett, 1981, pp. 348, 351). Total length of stem unknown, but hardly any gradation in size or morphology noted in longest preserved segments.

Brachiole segments up to 6 mm long also preserved in acid residues (Plate 2, Figs. 23–24); brachioles ridged, roughly pentagonal in cross section, biserially plated (Text-Fig. 11F); brachiolar plates about 0.3 mm long, 0.33 mm wide, and 0.15 mm deep (across food groove), possibly one biserial set of slightly domed, triangular, brachiolar cover plates over shallow, V-shaped food groove (Text-Fig. 11F), about three brachiolar cover plates per brachiolar plate on each side.



Text-Figure 12. Growth plots for 11 measured specimens (MCZ 915–923 plus two extras) of *Koryschisma elegans*, n. gen., n. sp., set up in a similar format to that used by Breimer and Macurda (1972, textfig. 72) for this same (then unnamed) species. Differences include the addition of a graph for vault vs. pelvis (top center), lower values for the RD growth front and maximum deltoid width (because we measured only the small external part on the thecal surface), and a different order to the plots. Best-fit lines in all plots were hand fit, and short lines with a central tick mark (top center) indicate estimated values in broken specimens.

Growth features described by Breimer and Macurda (1972, p. 219, textfig. 72) and in Text-Figure 12; their growth series specimens ranging from 5.8 to 12.5 mm in length, ours from 9.0 to 19.0 mm. One abnormal individual (UMMP 60688) found in 145 studied specimens (0.7%); D ambulacrum absent from its ambulacral sinus and E ambulacrum triserial, wider than normal, with two main food grooves (D? and E) running most of length (Plate 2, Fig. 39).

Studied Specimens. Holotype MCZ 915, paratypes MCZ 916–961 (15 complete or partial thecae, 9 stem segments or columnals, 20 separate plates and ambulacral fragments, 3 brachiole segments) and UMMP 60679-60694 and 65893 (16 complete specimens measured by Breimer and Macurda [1972] plus one other theca). Additional material in collections MCZ 962 and 1062 and UMMP 1970/M-171.

Etymology. Elegans (Latin), choice, fine, refers to the excellent preservation shown by the silicified specimens of this species.

Occurrence. All material (except for one possible basal plate) from the middle Lodgepole Limestone about 170–175 ft (52–53 m) above the base of the Paine Member, on the west face of Bandbox Mountain, Little Belt Mountains, west-central Montana (see Text-Fig. 5). MCZ 1062, a basal plate with distinctive secondary deposits that may belong to this species, is from the upper Lodgepole Limestone (Woodhurst Member) about 655 ft (200 m) above the base at Sacagawea Peak, Bridger Range, southwestern Montana.

Discussion. Koryschisma elegans is most closely related to the forms described as *Phaenoschisma*? *saharae* Breimer and Macurda (1972, pp. 18–20), Macurda (1983, pp. 61–65) and *Phaenoschisma*? *parvum* Macurda (1983, pp. 60–61), which are here reassigned to *Koryschisma* as separate species. *Koryschisma elegans* differs from *K. parvum* by having a larger and more elongate theca (higher L/W ratio), wider crests, more hydrospire slits, and is slightly older (Kinderhookian vs. Osagean).

⟶

PLATE 3

Figures 1–16. *Orophocrinus macurdai* Sprinkle and Gutschick, n. sp., lower Paine Member, lower Lodgepole Limestone, 1, 3, 5, 9, 11, and 13–16 from Milligan Canyon East, 2, 4, 6–8, 10, and 12 from Dry Hollow, southwestern Montana. 1, B-side view of smallest paratype MCZ 812, ×2.3; 2, 8, B-side and top views of small conical paratype MCZ 813 showing large stem facet, ×2.3; 3, 9, E-side and top views of small wide paratype MCZ 815; note convex ambulacra and spiracular slits, ×2.3; 4, 10, B-side and top views of medium paratype MCZ 817 showing missing hypodeltoid, ×2.3; 5, 11, C-side and top views of medium paratype MCZ 818; note conical shape and relatively short ambulacra, ×2.3; 6, E-side view of medium wide paratype MCZ 821, ×2.3; 7, C-side view of large, slightly-crushed paratype MCZ 822 showing convex ambulacra and coarse HD ornament on C radial, ×2.3; 12, top view of medium paratype MCZ 819 with hypodeltoid still in place, ×2.3; 13–16, E-side, BC-side, top, and oblique top, respectively, of very large crushed holotype MCZ 811 in slab; note missing basals, growth lines on radials, long lanceolate ambulacra, and hypodeltoid in place over anus, ×2.3 and ×3.

Figures 17–24. *Orophocrinus* cf. *O. gracilis* (Meek and Worthen), lower Paine Member, lower Lodgepole Limestone, 17–18, and 22–24 from Standard Creek, 19–20 from Dry Hollow, and 21 from Little Antelope Creek, southwestern Montana. 17–18, AB-side and top views of smallest apparent specimen MCZ 840 showing weathered pelvis and longer ambulacra than 1–6 above, ×2.3; 19–20, front and back of medium, vertically-crushed specimen MCZ 838 in slab; note long ambulacra and trace of internal hydrospires, ×2.3; 21, side view of large, badly-crushed specimen MCZ 839 showing long ambulacra and growth lines on radials, ×2.3; 22–24, front, separate ambulacrum and deltoid from front, and back of large crushed and eroded specimen MCZ 836 in slab; note thecal shape, long ambulacra, vault longer than pelvis, and deltoid shape, ×3.

Figures 25–27. *Orophocrinus* sp., Woodhurst Member, upper Lodgepole Limestone, Baldy Mountain, Bridger Range, southwestern Montana; top, E-side, and basal views of medium-sized specimen MCZ 884 showing badly-etched surface, thecal shape, concave ambulacra, and small hole in basal (27), ×2.5.

Figure 28. *Phaenoschisma*? sp., float from Woodhurst Member, upper Lodgepole Limestone, Saddle Peak, Bridger Range, southwestern Montana; side view of small specimen MCZ 885 before excavation from slab; note elongate shape and short ambulacra, ×6.

Figure 29. *Hadroblastus* sp., float from middle Lodgepole Limestone, Standard Creek, southwestern Montana; side view of partly-excavated specimen MCZ 748 showing crushed theca, fully-exposed hydrospires, attached proximal stem, and few brachioles from left ambulacrum, ×2.

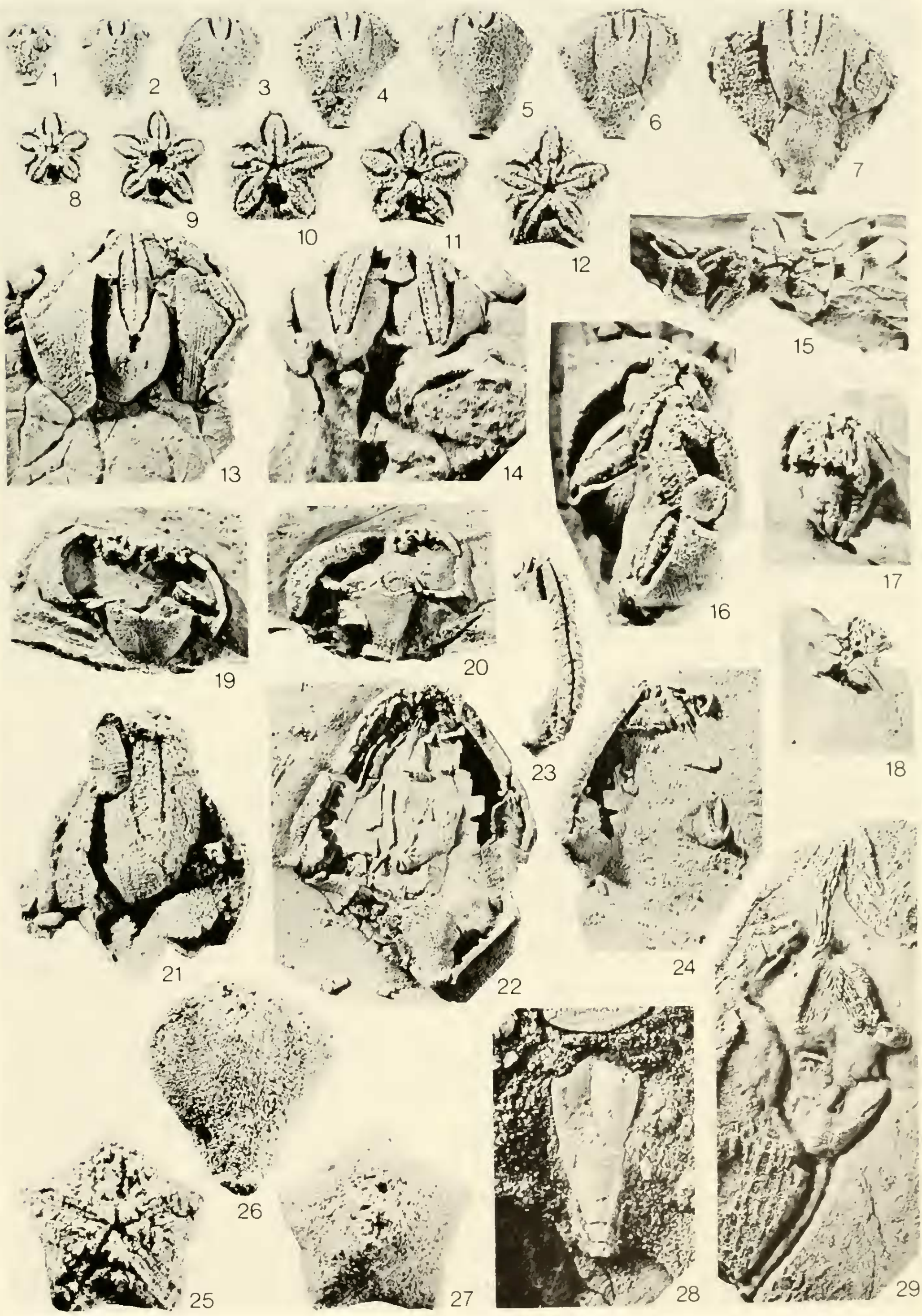

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TABLE 4. MEASUREMENTS FOR LODGEPOLE BLASTOID SPECIES THAT HAD FOUR OR FEWER MEASURABLE SPECIMENS. MEASUREMENTS ARE THE SAME AS THOSE USED FOR THE GROWTH PLOTS (FOR EXAMPLE, SEE →

Species and specimen number	Length (mm)	Width (mm)	Vault (mm)	Pelvis (mm)	Pelvic angle	St. fac. (mm)	BR axis (mm)	RB axis (mm)
Phaenoschisma? sp.								
MCZ 885	5.2	~3.2	~0.6	~4.6	45°	~0.8	>2.9	~2.0
Hadroblastus sp.								
MCZ 748	16.2	~12.0	6.0	10.1	—	1.1	~6.1	~4.4
Orophocrinus cf. *O. gracilis*								
MCZ 840	6.8	6.5	2.6	4.2	~65°	~1.2	~2.4	~2.0
MCZ 836	16.1	~15.1	8.7	7.5	~95°	1.6	4.6	>4.3
MCZ 838	—	—	—	—	~70°	2.3	4.6	~6.5
MCZ 839	—	—	~10.0	—	—	—	—	>6.0
Orophocrinus sp.								
MCZ 884	14.0	13.1	4.8	9.2	75°	2.8	4.0	5.5
Metablastus milliganensis								
MCZ 804	~11.0	6.4	5.7	5.2	~60°	—	~3.5	2.9
MCZ 803 (Holotype)	11.0	6.6	4.6	6.4	~55°	0.8	3.7	3.2
MCZ 805	~13.7	8.2	6.0	~7.7	~50°	—	—	—
Montanablastus baldyensis								
MCZ 889	6.4	5.0	3.0	3.3	~75°	~0.6	1.8	1.6
MCZ 893	7.7	~5.6	3.8	3.9	~65°	0.7	1.9	2.0
MCZ 886 (Holotype)	8.6	6.5	5.1	~3.6	80°	~0.9	1.9	2.3
MCZ 892	10.2	7.3	5.7	5.1	75°	0.7	2.5	2.8

Koryschisma elegans differs from *K. saharae* by being less elongate (lower L/W ratio), having a higher V/P ratio, higher crests with wider ambulacra, a longer, more pointed hypodeltoid, and by being considerably older (Late Tournaisian equivalent vs. Late Visean to Early Namurian).

KORYSCHiSMA SAHARAE (Breimer and Macurda), 1972

Pentremites sp., Pareyn, 1961, pp. 223–224.
Phaenoschisma? saharae, "*Phaenoschisma*" *saharae*, Breimer and Macurda, 1972, pp. 18–20, 387, plate II, figures 4–5 and 10; Macurda, 1983, pp. 61–65, plate 14, figures 1–13, table 21.

Diagnosis. Theca large, elongate conical, L/W averages 1.71, pelvis much longer than vault, V/P averages 0.23, pelvic angle averages 38°; deltoid crests low to medium, hypodeltoid large, other deltoids appear confined to ambulacral sinuses; ambulacra nearly linear, lancet making up about one-fourth of width; 5–9 hydrospire slits per group, number reduced by about one-third on anal side; subdued secondary deposits at tip of basals.

Discussion. This species, from the Late Visean and Early Namurian of Algeria, is larger and more elongate than *K. elegans* and *K. parvum*, with a shorter vault, narrower ambulacra, lower crests, and more subdued secondary deposits around the large stem facet.

KORYSCHISMA PARVUM (Macurda), 1983

"UA (undescribed phaenoschismatid A . . .); phaenoschismatid (UA)," Breimer and Macurda, 1972, pp. 217–219, plate IV, figures 17, 20, plate V, figures 1–2, textfigure 71.
Phaenoschisma? parvum, Macurda, 1983, pp. 60–61, plate 13, figures 9–10, 14–17, 19–20, 23–24, table 19.

Diagnosis. Theca small, widely biconical, L/W averages about 1.1, pelvis longer than vault, V/P averages about 0.57, pel-

(*continued*) TEXT-FIGURE 12). A ~ PRECEDING A NUMBER INDICATES THAT THIS MEASUREMENT WAS ESTIMATED IN A DAMAGED, INCOMPLETE, OR CRUSHED SPECIMEN; SPECIMENS WITH A — WERE TOO INCOMPLETE OR DAMAGED TO MEASURE.

RR front (mm)	RR axis (mm)	RR front (mm)	RD axis (mm)	RD front (mm)	Del. len. (mm)	Del. wid. (mm)	Amb. len. (mm)	Amb. wid (mm)	No. of side pls.
~1.1	0.9	2.0	~1.0	—	—	—	~1.5	~1.0	—
~4.6	3.3	5.6	4.7	2.3	~4.5	~4.3	~6.5	~1.2	>18
—	2.0	—	3.0	0.4	1.4	0.9	4.2	1.0	15
—	~4.3	—	7.2	1.2	3.0	2.1	>9.2	>1.3	~19
~4.5	5.0	~7.0	7.1	1.3	—	~2.2	>9.0	~2.0	>20
—	5.5	>9.2	9.2	1.2	4.9	2.4	11.2	1.7	28
~4.5	4.1	~8.0	~5.0	1.6	3.5	2.0	7.1	1.7	~29
2.5	1.8	7.3	5.5	<0.1	<0.1	<0.2	5.4	0.8	~19
2.5	1.9	6.9	5.7	<0.1	<0.1	<0.2	5.1	0.7	20
2.5	—	—	~6.9	<0.1	<0.1	<0.2	6.5	0.7	~23
1.5	1.1	3.7	3.0	~0.2	0.7	~0.4	2.9	0.8	13
1.8	1.6	~5.0	3.9	—	~0.7	—	4.3	1.0	15
2.2	1.7	5.7	4.7	~0.3	0.9	0.6	4.6	1.0	16
~2.8	2.2	~7.0	5.6	0.8	~1.9	~0.9	6.2	>0.7	~15

vic angle averages 67°; deltoid crests high, slope down to mouth, hypodeltoid relatively large, on thecal surface, other deltoids confined to ambulacral sinuses; ambulacra lanceolate, lancet only slightly exposed in center; 4–6 hydrospire slits per group, number slightly reduced on anal side.

Discussion. This species, from the Osagean of New Mexico, is smaller and much wider than *K. elegans* and *K. saharae*, with a shorter vault, higher deltoid crests, and fewer hydrospire slits. Because of its small size, it may be a paedomorphic derivation of the slightly older *K. elegans*.

Genus PHAENOSCHISMA Etheridge and Carpenter, 1886

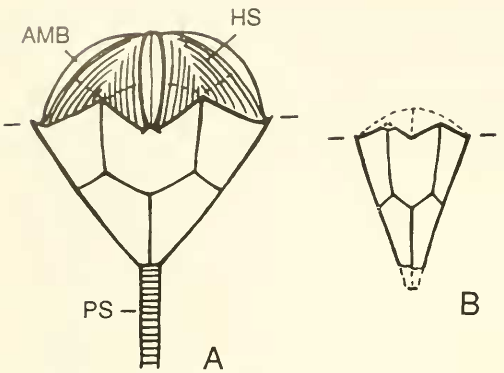
Type Species. *Pentatrematites acutum* Sowerby, 1834.

Diagnosis. Fissiculate blastoids with a conical to obconical theca; 10 hydrospire groups having slits partly exposed, number of slits slightly reduced on anal side; two anal deltoids, hypodeltoid small, not on thecal surface; ambulacra lanceolate, lancet widely exposed.

Occurrence. Early to Middle Mississippian, central and western U.S.A., Early Carboniferous, England and Ireland.

PHAENOSCHISMA? SP.
Plate 3, Figure 28;
Text-Figure 13B; Table 4

A single small specimen of an apparent phaenoschismatid was found in the float near the top of the Lodgepole Limestone at Saddle Peak in the Bridger Range. It was preserved as a crushed but nearly complete calcitic theca on a slab (Plate 3, Fig. 28); the theca was extracted using an air abrasive unit, but unfortunately it proved to be incomplete with only the basals and radials still preserved. Theca about



Text-Figure 13. A, reconstructed side view of *Hadroblastus* sp. based on MCZ 748; note thecal shape (greatest width at short lines), wide ambulacral sinuses with hydrospire slits (HS) exposed, curved raised ambulacra (AMB), and size of proximal stem (PS), ×1.8. B, slightly reconstructed side view of *Phaenoschisma*? sp. (MCZ 885) showing shape (greatest width at short lines), long basals and radials, and inferred shape of missing vault with short ambulacra, ×3.8.

5.0 mm long with incomplete base and missing deltoids and ambulacra, original length at least 5.2 mm, maximum width (crushed) 3.9 mm, original width estimated at 3.2 mm; pelvis about 4.6 mm long and incomplete vault at least 0.6 mm long. L/W ratio probably near 1.5–1.6 originally, V/P ratio about 0.13 originally, and pelvic angle now 40° on crushed side.

Pelvis conical, straight to slightly concave in profile; basals three, appear normally arranged with two larger, one smaller, pointed at top, occupy 50–60% of preserved pelvis, about 2.9 mm long with small amount added for missing stem facet; stem facet slightly triangular, secondary deposits not observed. Radials five, pentagonal, occupy slightly less of pelvis than basals, notched at top for ambulacra and deltoids, notch on apparent posterior side larger than others implying external hypodeltoid possibly present (Text-Fig. 13B), regular deltoids small.

No deltoids or ambulacra preserved, only ends of hydrospire slits on adoral edges of radials, apparently at least four hydrospire slits per ambulacral side. Other summit structures unknown.

The only theca is MCZ 885 which was found in the float about 100–200 ft (30–61 m) below the top of the Lodgepole Limestone at Saddle Peak, southern Bridger Range, southwestern Montana.

Discussion. This single specimen is too incomplete to tell whether it belongs to the genus *Phaenoschisma*, but this is considered the most likely possibility based on its preserved morphology and Early Mississippian age. It is rather similar in side view to *P. laevisculum* and to *P. gracillimum* (see Breimer and Macurda, 1972, plate 3, figures 14, 19, and 26–27), both from the similar-aged Burlington Limestone. These species are somewhat larger, differ slightly in their thecal proportions, and do not have an enlarged hypodeltoid contributing to the posterior thecal surface. This is the only relatively complete theca of a possible *Phaenoschisma* known from the Lodgepole Limestone, but a few elongate basals perhaps belonging to a similar blastoid are also known from the lower fauna in the Allan Mountain Limestone at the North Sawtooth Mountain Section in northwestern Montana.

Family NEOSCHISMATIDAE Wanner, 1940
Genus HADROBLASTUS Fay, 1962c

Type Species. Hadroblastus convexus Fay, 1962c.

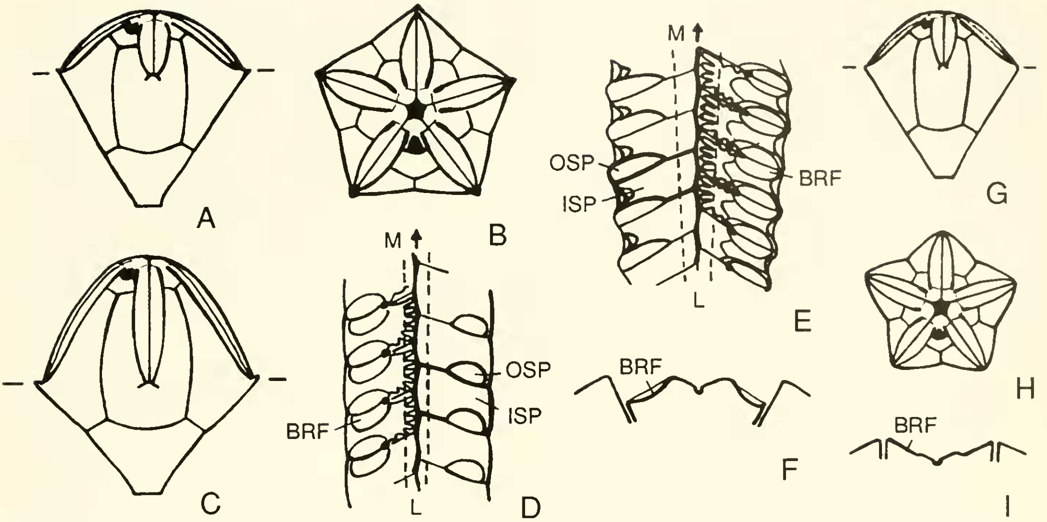
Diagnosis. Fissiculate blastoids with biconvex theca, vault usually shorter than pelvis, deltoid crests low to medium; 10 hydrospire groups, slits almost completely exposed in wide shallow sinuses alongside ambulacra, slits usually reduced on anal side; two anal deltoids, epideltoid forms anal hydrospires, hypodeltoid forms part of theca wall; ambulacra lanceolate, often raised, lancet exposed throughout length.

Occurrence. Early to Middle Mississippian, central and western U.S.A.; Early Carboniferous, Ireland? and Scotland?

HADROBLASTUS SP.
Plate 3, Figure 29;
Text-Figure 13A; Table 4

Hadroblastus sp., Breimer and Macurda, 1972, pp. 30, 382, plate 18, figure 1.

A single specimen from an unknown position in the middle Lodgepole Limestone was found at Standard Creek, southwest-



Text-Figure 14. Morphology of *Orophocrinus macurdai*, n. gen., n. sp., (A–B, E–F), *Orophocrinus* cf. *O. gracilis* (Meek and Worthen) (C–D), and *O.* sp. (G–I). A–B, side and summit views of a large theca (based on MCZ 821 and holotype MCZ 811) showing shape, maximum width (short lines), fairly wide ambulacra with spiracular slits alongside, slightly concave interambulacra, and size and shape of hypodeltoid. C, reconstructed side view based on MCZ 836 showing shape, longer ambulacra, and location of greatest width (short lines) near midheight. D, enlarged plan view of ambulacrum in MCZ 836 showing lancet (L) slightly exposed in center (small arrow points toward mouth [M]), large inner and small outer side plates (ISP and OSP) occupying most of width and supporting a brachiole facet (BRF) near edge, ×9.5. E–F, enlarged plan view and cross section of ambulacrum in paratype MCZ 823; note lancet (L) exposed in center, large inner and small elongate outer side plates (ISP and OSP) together supporting an elliptical brachiole facet (BRF), well-developed cover plate lobes and sockets, and convex cross-sectional shape with depressed, outward-slanting facets, ×11.8. G–H, side and summit views of MCZ 884 showing similarity in thecal shape to A and B except for more concave interambulacra. I, cross section of E ambulacrum in MCZ 884 showing concave surface with inward-slanted brachiole facets (BRF) quite different from F, ×7.1.

ern Montana. This specimen was figured by Breimer and Macurda (1972) using a pre-preparation photograph supplied by Sprinkle in 1966. Subsequently, the specimen was partly uncovered using an air abrasive unit although the matrix proved too hard and deep to uncover an entire side (Plate 3, Fig. 29). Part of the proximal stem was also found still attached to the theca.

Description. Only known specimen partly buried and crushed on slab with exposed plates silicified. Theca fairly large, apparently biconvex, 16.2 mm long, at least 12 mm wide (incomplete but crushed), vault 6.0 mm long, pelvis 10.1 mm long, L/W ratio approximately 1.35 based on exposed width, V/P ratio 0.59. Pelvic angle difficult to measure, perhaps 70–80° originally (Text-Fig. 13A).

Basals fairly long, occupying 50–60% of pelvis, at least 7 mm long, azygous basal quadrate in shape, about 3.5 mm wide. Radials fairly large, about 6.5 mm long, perhaps as much as 6.5 mm wide, radial body about 4.5 mm long, shallow ambulacral sinuses about 2 mm long. Deltoids difficult to see, occupying broad ambulacral sinuses, approximately 3.5 mm long and about 3.5 mm wide, little or no deltoid crest present. Ambulacra occupying centers of broad ambulacral sinuses, at least 6.5 mm long and about 1.2 mm wide, appear to be flat to slightly convex in cross section, strongly convex in lateral view and considerably raised above surrounding sinuses (Text-Fig. 13A), too highly silicified to distinguish lancet or side plates. Hydrospires fully exposed, apparently 7–8 per ambulacral side, longest slits extending nearly full length of adjacent ambulacra, slits converge at center-line of deltoid which is not raised into crest above sinuses.

Few brachioles attached to left ambulacrum in this specimen, brachioles incomplete, about 10–11 mm long, approximately 0.3 mm wide and deep, poorly preserved because of partial silicification (Plate 3, Fig. 29).

Proximal stem attached to facet on basals, preserved stem about 12.5 mm long extending off edge of slab (Plate 3, Fig. 29), about 1 mm in diameter both proximally and distally, made up of at least 47 columnals varying from about 0.17 mm long proximally to about 0.33 mm long distally.

Ornament on thecal plates difficult to see because of silicification and abrasion of plates during preparation, no trace of coarse ornament or growth lines.

Material and Occurrence. Only known specimen is MCZ 748 from an unknown height in the middle Lodgepole Limestone, slab found in the float above the lower cliffs containing *Tanaoblastus* at Standard Creek, Gravelly Range, southwestern Montana.

Discussion. This blastoid from the middle Lodgepole Limestone may represent a new species of *Hadroblastus*, but is not named here because the only known specimen is not well preserved or exposed. This form is larger and more elongate than the type species *H. convexus* Fay (1962c), which has a small squat theca with a low vault and moderate deltoid crests. It has a higher vault with lower deltoid crests than *H. breimeri* Ausich and Meyer (1988). It differs from *H. whitei* by having longer hydrospire fields without deltoid crests and perhaps fewer slits (7–8 vs. 9–10). It may have been similar to *H. blairi*, especially in ambulacral height and curvature, but was less squat and had almost no deltoid crests.

Family OROPHOCRINIDAE Jaekel, 1918
Genus OROPHOCRINUS von Seebach, 1864

Type Species. Pentremites stelliformis Owen and Shumard, 1850.

Diagnosis. Fissiculate blastoids having a conical, conoidal, or parachute-shaped theca, ten long spiracular slits and hydrospire groups alongside ambulacra; 4–11 hydrospire folds per group; two anal deltoids present, relatively small epideltoid with long aboral limbs and relatively small hypodeltoid visible on thecal surface; ambulacra relatively wide, usually raised, lancet narrowly exposed along much of length.

Occurrence. Early to Middle Mississippian, central, southwestern, and northwestern United States; Early Carboniferous (Tournaisian and Visean), Belgium, Great Britain, and Ireland.

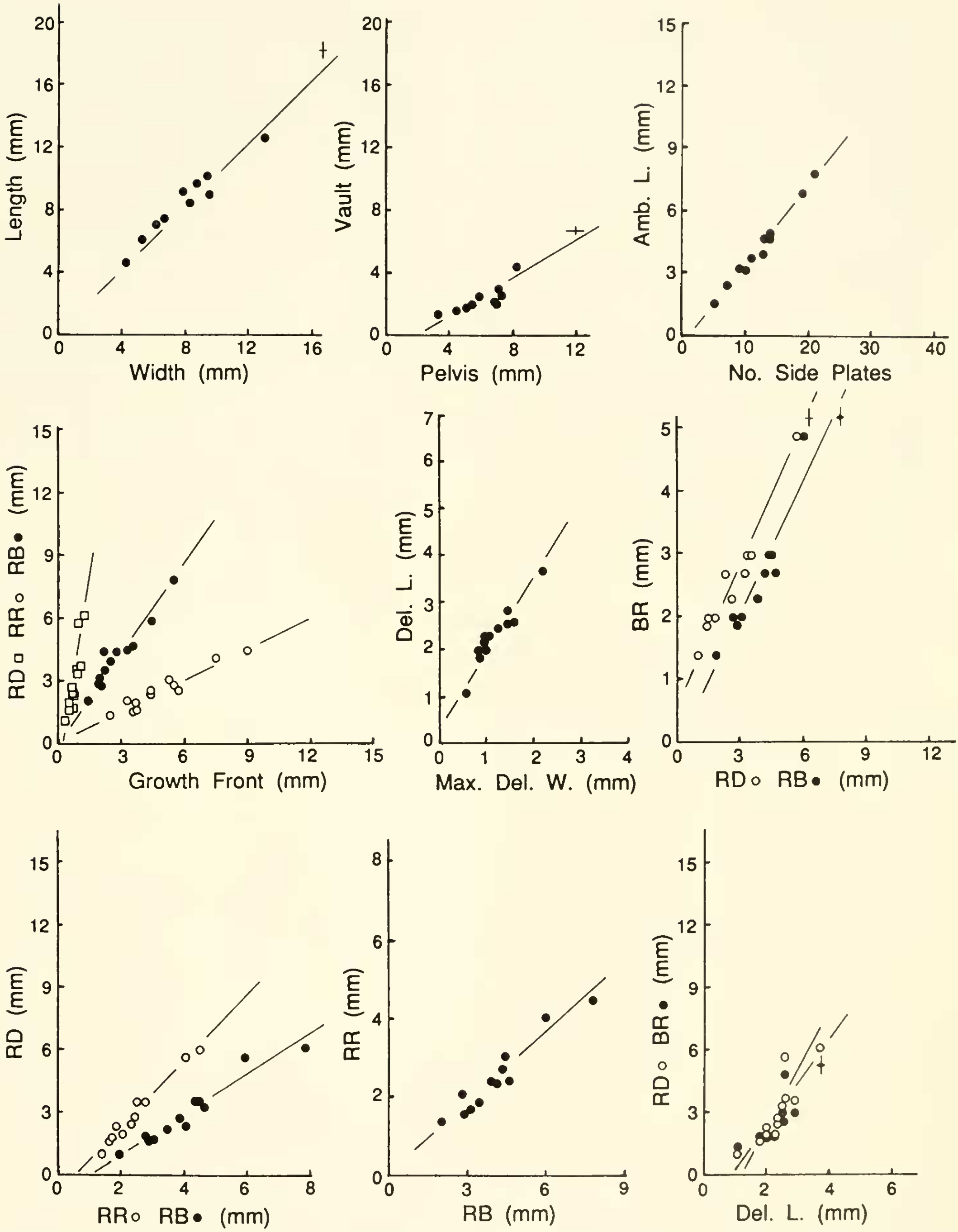
Discussion. Two species of *Orophocrinus* occur in the lower Lodgepole Limestone, and an additional specimen of a third species occurs in the upper Lodgepole Limestone of southwestern Montana. These occurrences extend the geographic range of this genus into the northwestern United States. *Orophocrinus* is a very wide-ranging genus in the Mississippian (Early Carboniferous) known from both North America and Europe. It differs from similar genera in the Orophocrinidae such as *Brachyschisma* by having a full set of anal hydrospires and only two anal deltoids, from *Katoblastus* by having the hydrospire slits completely hidden and only two anal deltoids, and from *Pentablastus* and *Acentrotremites* by having a different thecal shape with ambulacra that do not usually extend down the theca.

OROPHOCRINUS MACURDAI Sprinkle and Gutschick, new species

Plate 1, Figure 2; Plate 3, Figures 1–16; Text-Figures 14A–B, E–F, and 15

Diagnosis. Theca conical, L/W ratio averaging 1.07, V/P ratio averaging 0.29, pelvic angle averaging 64°, interambulacra flat to slightly concave, RD axis less than RB axis at all sizes, hypodeltoid widely borders spiracular slits, ambulacra strongly convex, brachiolar facets abmedial, usually five hydrospire folds per ambulacral side.

Description. Forty-one specimens and fragments available for study; description based on holotype MCZ 811, 11 additional



Text-Figure 15. Growth plots for the 12 measured specimens (MCZ 811–822) of *Orophocrinus macurdai*, n. sp. Best-fit lines in all plots were hand fit, and short lines with central tick mark represent estimates for large incomplete holotype MCZ 811 that lacks basals.

complete paratypes in growth series, and 12 other paratype specimens and fragments. Theca conical, made up mostly of conical pelvis with straight to slightly convex sides, capped by convex vault (Text-Fig. 14A); growth series specimens ranging from 4.5 mm long to incomplete holotype 13.2 mm long (no basals; original complete length estimated at 18.2 mm). In 12-specimen growth series, L/W ratio ranging from 0.88 to 1.18 and averaging 1.07, decreasing slightly during growth; V/P ratio ranging from 0.29 to 0.65 and averaging 0.41 for same specimens, increasing slightly late in ontogeny; pelvic angle ranging from 50° to 85° and averaging 64°, increasing slightly during growth. Greatest width at tips of ambulacra, well above midheight; cross section here pentagonal, interambulacral areas flat to slightly concave (Plate 3, Figs. 8–12).

Basals three, normally arranged, two regular and one small (azygous), azygous basal quadrate, 3.0 mm long, 3.1 mm wide in medium-sized specimen, regular basals hexagonal, about same length and 4.3 mm wide, basals making up about 40% of pelvis (Plate 3, Figs. 5–7); some secondary deposits extending short distance up interbasal sutures from large round to somewhat triangular stem facet 1.7 mm in diameter, with 0.2 mm lumen in center.

Radials five, relatively long, RD axis less than RB axis at all sizes (Text-Fig. 15), 2 mm less in very large holotype (Plate 3, Fig. 13), RD front nearly straight except on posterior side where distinctly concave against hypodeltoid, large lip at radial origin pointing obliquely adoral.

Regular deltoids four, relatively narrow, elongate hexagonal. Adoral part bulbous, with several thick overlayerings of secondary calcite, middle part constricted, strongly concave in profile with raised ridge alongside adoral end of each spiracular slit, aboral part slightly concave in profile (Plate 1, Fig. 2), ornamented with medium, regularly spaced, growth lines. DR sutures nearly straight, forming 150–160° angle, radials slightly overlap deltoids. Mouth pentagonal to star-shaped, surrounded by regular deltoid and epideltoid lips.

Anal deltoids two, hypodeltoid fairly small, squat pentagonal, easily lost (Plate 3, Figs. 8–11); extends further down theca than adjacent regular deltoids, entire lateral margins border spiracular slits, sutures with radials often moderately curved, adoral edge usually raised in center forming hood over anus (Plate 3, Fig. 16). Epideltoid having small, pentagonal, adoral part bordering mouth and anus on opposite sides, and two long aboral limbs extending down alongside anus and under hypodeltoid, epideltoid limbs infolded to form hydrospire folds below spiracular slit. Anus elliptical with hypodeltoid in place (Plate 3, Fig. 12), about same size as mouth.

Ambulacra five, relatively short and wide, 7.5 mm long and 1.9 mm wide in very large holotype, in shape changing from petaloid to lanceolate during growth, strongly convex in cross section, even with or slightly raised above adjacent plate margins (Plate 3, Figs. 1–7), lancet exposed, making up central 20% in adoral two-thirds of ambulacrum (Text-Fig. 14E). Inner and outer side plates supported by lancet, inner side plates grow laterally as they move up ambulacrum, forming raised abmedial lip around outside of large elliptical brachiolar facets which are abmedial (Plate 3, Fig. 14), 8–9 side plate sets per 3 mm length of ambulacrum, tiny brachiolar pit at end of each food groove near highest point on each side of ambulacrum (Text-Fig. 14F). For each side plate, 3–4 lobes along main food groove plus 3–4 lobes adorally and 2–3 lobes aborally along side food groove (Text-Fig. 14E).

Spiracular slits 10, slightly arcuate, moderately long, extending about two-thirds of ambulacral length, few millimeters of aboral end closed off internally by radial growth beneath lancet, adoral end near narrowest point on deltoid, slits do not quite reach adoral edge of anus in CD interray (Text-Fig. 14B). Hydrospires usually five per ambulacral side (10 measurements), possibly four in few cases, possibly six in one case, top slit about 0.6 mm deep below deltoid edge adorally, aboral end of this slit sometimes visible near radial lip when ambulacrum damaged or side plates missing, enlarged tube apparently present at inner end of each hydrospire fold.

Ornament consists of medium-strength, widely spaced, growth lines (Plate 1, Fig. 2; Plate 3, Fig. 13) on basals, deltoids, and most of radials; RD front of radials consists of coarse, widely spaced, growth lines (Plate 3, Figs. 7 and 14). Secondary deposits present around stem facet, at radial origin and along edges of ambulacra, and over adoral parts of deltoids (probably filling in adoral ends of spiracular slits).

Measurements of specimens in growth series graphed in Text-Figure 15.

Stem, brachioles, and cover plates unknown.

Studied Specimens. Holotype MCZ 811, paratypes MCZ 812–834 (23 specimens and fragments), and MCZ 835 (17 additional fragments).

Occurrence. Known from the lower Lodgepole Limestone at five localities in southwestern Montana; 20 specimens and fragments from Dry Hollow 20–50 ft (6–15 m) above the base of the Paine Member, the holotype and 14 other specimens and fragments from Milligan Canyon East 12–20 ft (3.7–6 m) above the base, four specimens and fragments from Milligan Canyon 15–20 ft (4.5–6 m) above the base, and single specimens from Sand Creek 23 ft (7 m) above the base and from Little Antelope Creek in the float 20–50 ft (6–15 m) above the base.

Etymology. Named for D. Bradford Macurda, Jr., of The Energists, Houston, who revised this genus and its species in the 1960s.

Discussion. Orophocrinus macurdai is a fairly distinctive species and represents one of the earliest occurrences of the genus. It differs from other similar species, such as *O. orbignyanus* and *O. conicus*, by having a conical shape throughout its growth with length slightly greater than width, vault much greater than pelvis, a moderate pelvic angle, RD less than RB at all sizes, hypodeltoid widely bordering the spiracular slits, convex ambulacra with abmedial brachiole facets, and usually five hydrospires per ambulacral side. *Orophocrinus macurdai* is probably most closely related to *O. orbignyanus* of Belgium and perhaps to *O. conicus* from the Late Kinderhook of the Mississippi Valley; all of these species are nearly the same age. *Orophocrinus macurdai* has only been found in a thin east-west strip of sections near the center of the study area in southwestern Montana (see Text-Fig. 8).

Five additional poorly preserved specimens of *Orophocrinus* also from the lower Lodgepole have a different thecal shape with much longer ambulacra than *O. macurdai* and apparently belong to a species very similar to *O. gracilis* from the Late Kinderhook and Osage of the Mississippi Valley.

OROPHOCRINUS cf. O. GRACILIS (Meek and Worthen), 1870

Plate 3, Figures 17–24;
Text-Figures 14C–D; Table 4

Diagnosis. Theca conoidal, L/W ratio about 1.1, V/P ratio about 1.3, pelvic angle about 83°, RD axis much greater than RB axis, hypodeltoid borders spiracular slits, ambulacra long, convex in cross section, raised above thecal plates, brachiolar facets abmedial to central, 4–5 hydrospires per ambulacral side.

Description. Five poorly preserved and fragmentary specimens available closely resembling this species. Theca conoidal, pelvis broadly conical, sides of pelvis nearly straight, vault parabolic with long ambulacra extending down theca (Text-Fig. 14C; Plate 3, Fig. 22). Smallest apparent specimen 6.8 mm long, largest approximately 19 mm long (basals missing). L/W ratio 1.0 and 1.2 in two nearly complete specimens, V/P ratio ranges from 0.6 to 1.46, pelvic angle averages 83° in three incomplete and crushed specimens. Greatest width at tips of ambulacra well below midheight, cross section here pentagonal with slightly concave interambulacra.

Basals three, normally arranged, two larger and one smaller (azygous) make up nearly 50% of pelvis; in large specimen azygous basal quadrate 5.2 mm long, approximately 4.5 mm wide, larger basals same length, about 6.2 mm wide. Stem facet large, 2.4 mm in diameter with small central lumen 0.1 mm wide; small secondary deposits up interbasal sutures to produce circular facet.

Radials five, long, RD much greater than RB in all but smallest specimen, nearly 3 mm longer in largest theca, RD front nearly straight, fairly large lip at radial origin pointing laterally (Plate 3, Fig. 22).

Regular deltoids four, relatively narrow, elongate hexagonal. Adoral part with 1–2 concentric growth lines, middle part constricted, concave, aboral part slightly concave in profile, growth lines subdued (Plate 3, Fig. 24). DR sutures nearly straight, form 160° angle, radials appear to overlap deltoids.

Anal deltoids apparently two, missing or poorly preserved on all specimens except smallest where epideltoid present (Plate 3, Fig. 18). Hypodeltoid not seen but probably reaches spiracular slits because epideltoid limbs depressed below thecal surface. Epideltoid has small pentagonal part bordering mouth and anus plus two depressed limbs extending aborally and infolded to form hydrospires. Anus probably elliptical in shape with hypodeltoid present.

Ambulacra five, long and fairly narrow, raised above adjacent thecal plates, linear to lanceolate, moderately convex, lancet exposed in center along much of length (Plate 3, Figs. 23–24). Inner and outer side plates supported by lancet, side plates apparently do not grow laterally, brachiole facets appear to be abmedial or perhaps central (Text-Fig. 14D). Longest ambulacra 11.5 mm long and 2.0 mm wide with about 25 side plate sets, over much of ambulacrum six side plates per 3 mm length; five lobes along main food groove and 1–2 more along adoral edge of side food grooves (Text-Fig. 14D).

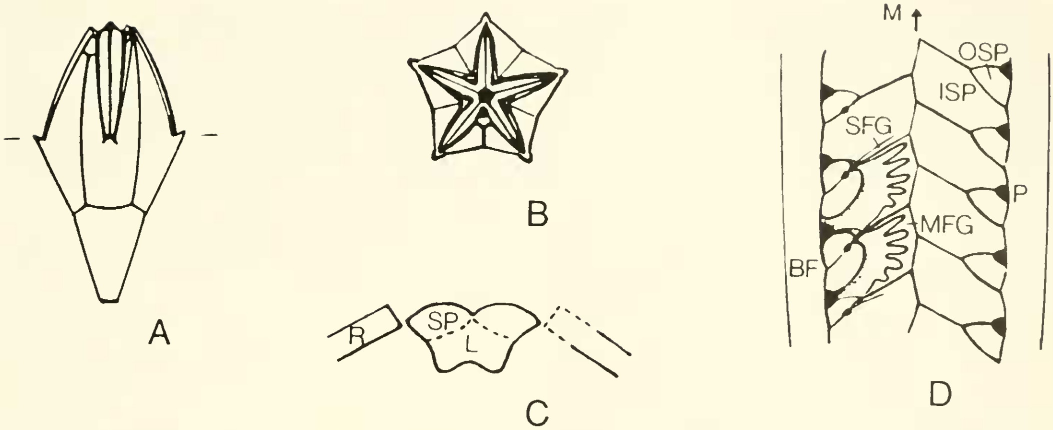
Spiracular slits 10, long, nearly linear, appear to extend most of ambulacral length but aboral 2–3 mm closed off by radial growth beneath lancet, adoral end at narrowest point on deltoids. Either four or five folds per ambulacral side (two observations), folds thin with enlarged tube apparently present at bottom (Plate 3, Fig. 22).

Ornament consists of medium-strength growth lines parallel to plate margins (Plate 3, Fig. 24). Measurements for few known specimens listed in Table 4.

Studied Specimens. MCZ 836–840 (five partial specimens).

Occurrence. Known from the lower Lodgepole Limestone at three localities in southwestern Montana: two specimens from the talus piles at Standard Creek from beds 15–55 ft (4.5–17 m) above the base of the Paine Member, two specimens from Dry Hollow 20–30 ft (6–9 m) above the base, and a single specimen from Little Antelope Creek 26–35 ft (8–11 m) above the base.

Discussion. These five poorly preserved specimens look somewhat different from specimens of *Orophocrinus macurdai*, with which they occur at two localities in Montana. Instead they closely resemble specimens of the distinctive Kinderhook and Osage form *O. gracilis* from the Mississippi Valley (see Macurda, 1965, pp. 1073–1077). The thecal shape and long ambulacra extending down the theca are very similar (compare Plate 3, Figs. 21–22). No hypodeltoid was seen, but it apparently borders the spiracular slits on both sides because the epideltoid limbs are depressed. The basal angle is similar, RD is much greater than RB in all except the smallest specimen (Table 4), the number of hydrospires is similar (four or five vs. four), and the brachiolar facets are in a similar position on the ambulacra. In addition, some specimens from the Mississippi Valley (*O.* cf. *O. gracilis* from the



Text-Figure 16. Morphology of *Metablastus milliganensis*, n. sp. A–B, side and summit views of reconstructed theca based on holotype MCZ 803 and paratype MCZ 804 showing greatest width (short lines) just above midheight and slightly concave interambulacra. C, enlarged cross-sectional view of broken ambulacrum in paratype MCZ 806; note that lancet (L) is "keeled" on the interior, covered externally by side plates (SP), and lacks hydrospires beneath it or the adjacent radials (R). D, much-enlarged plan view of ambulacrum in holotype MCZ 803 showing inner and outer side plates (ISP and OSP) covering lancet, pores (P) at edge of ambulacrum between brachiole facets (BF), and main food groove (MFG) and short side food grooves (SFG) bearing cover plate lobes and sockets. Small arrow points in direction of mouth (M).

Northview Shale of southwest Missouri; see Macurda, 1965, pp. 1075 and 1077) are nearly the same age as the Lodgepole material.

OROPHOCRINUS SP.
Plate 3, Figures 25–27; Text-Figures 14G–I; Table 4

A single coarsely silicified specimen of *Orophocrinus* was found near the top of the Lodgepole Limestone in the southern Bridger Range. The specimen was etched from the slab on which it was collected, and was found to differ from the two *Orophocrinus* species from the lower Lodgepole. However, it is not well enough preserved to establish a new species name for it, but is briefly described and figured here.

Description. Theca conical in shape with rounded vault and conical pelvis; fairly large theca 14.0 mm long, 13.2 mm wide, giving L/W ratio of 1.1; vault 5.1 mm long, pelvis 8.9 mm long, giving V/P ratio of 0.57; pelvic angle about 75° (Plate 3, Fig. 26). Theca pentagonal in summit view with slightly to moderately concave interambulacra, stem facet relatively large. Basals apparently three, fairly large, slightly convex in profile, occupy about 50% of pelvis. Radials five, long, occupy 50% of pelvis and most of vault, RB axis appears greater than RD axis, body slightly concave in profile, little or no radial lip at tip of ambulacra. Regular deltoids four, relatively short, form spiracular slits on margins with ambulacra, moderately concave in cross section. Anal deltoids two, not well preserved, hypodeltoid partly missing but appears to reach spiracular slit on each side, hypodeltoid slightly larger than other deltoid bodies. Ambulacra fairly long, only preserved in two or three rays, lanceolate, appear concave in cross section with raised margins against adjacent radials and deltoids and moderately depressed centers (Plate 3, Figs. 25–26), giving a wide V-shaped cross section (Text-Fig. 14I); lancet partly exposed in center, side plates numerous but not well preserved. Spiracular slits alongside ambulacra, apparently sealed aborally, probably extend half of ambulacral length or less, posterior spiracular slits do not quite reach adoral edge of anus. Summit structures poorly preserved.

Studied Specimen and Occurrence. MCZ 884 from a sequence of thick light beds near the top of the Woodhurst Member of the upper Lodgepole Limestone in the pass just south of Baldy Mountain, southern Bridger Range, southwestern Montana.

Discussion. This specimen with its concave ambulacra appears quite distinct from species of *Orophocrinus* found in the lower Lodgepole and from other previously described *Orophocrinus* species, none of which have flat or slightly concave ambulacra (see Macurda, 1965, table 2). The thecal shape indicates that this specimen is probably related to species such as *Orophocrinus orbignyanus, O. conicus,* and *O. macurdai*, n. sp. The concave ambulacra, fairly large stem facet, short spiracular slits, and anal deltoid morphology separate it from all of these species. If other specimens are found and confirm the described morphology, this form will eventually need to be described as a separate species.

Order SPIRACULATA Jaekel, 1918
Family TROOSTRICRINIDAE Bather, 1899
Genus METABLASTUS Etheridge and Carpenter, 1886

Type Species. Pentremites lineatus Shumard, 1858.

Diagnosis. Spiraculate blastoids having an elongate theca (usually biconical); four paired spiracles and a paired anispiracle, anus surrounded by an enlarged hypodeltoid, a smaller adoral superdeltoid, and two hidden cryptodeltoids; 2?–5 hydrospire folds per ambulacral side; ambulacra narrow, lancet completely covered by side plates, one pore per side plate along both radial and deltoid margins; hydrospire plate lacking; deltoids small, strongly overlapped by radials, not appearing on thecal plate surface except for enlarged hypodeltoid; basals sometimes flared with triangular stem facet.

Occurrence. Early to Middle Mississippian; Missouri, Illinois, Iowa, Indiana, Kentucky, and Montana.

Discussion. The discovery of a new *Metablastus* species in Montana extends the range of this genus down to the Kinderhookian. About half the described species have slightly to moderately flared basals with a triangular stem facet, apparently ancestral to the strongly flared basals of the genus *Tricoelocrinus.* The new species of *Metablastus* from Montana has non-flared basals with a round stem facet, and was probably ancestral to other Osagean and Meramecian species with the same feature. *Metablastus* differs from other closely related genera such as *Troosticrinus, Tricoelocrinus,* and *Costatoblastus* (see Sprinkle and Gutschick, 1967, p. 391) by having four anal deltoids, regular deltoids not visible in side view, lancet completely covered by the side plates, and a steeply conical to biconical theca without a strongly inflated base, plus its occurrence in the Mississippian.

METABLASTUS MILLIGANENSIS
Sprinkle and Gutschick, new species
Plate 4, Figures 1–13;
Text-Figure 16; Table 4

Diagnosis. Theca biconical, pelvis somewhat longer than vault, basals nonflaring with round stem facet, 2?–3 hydrospires per ambulacral side.

Description. Six partly complete specimens and two separate radial plates available for study; specimens thin-plated and most damaged during acid extraction; description primarily taken from holotype MCZ 803. Thecal shape nearly biconical with slightly expanding conical pelvis and rounded conical vault (Text-Fig. 16A). Holotype 11 mm long, 6.6 mm maximum width (crushed), original width estimated to be 5.5–6.0 mm. L/W ratio now 1.7 (crushed), original L/W ratio probably 1.8–2.0. Vault of holotype 4.6 mm long, pelvis 6.4 mm long, V/P ratio 0.69, probably unaffected by crushing. In two best paratypes, L/W and V/P ratios 1.76 and 0.91, plus 1.82 and 0.76, respectively. Basal angle in holotype now 55–60°, probably closer to 50° in original uncrushed specimen.

Maximum width at base of ambulacra above midheight. Interradial areas slightly concave; ambulacra slightly convex in cross section, only slightly depressed below surface of radials (Text-Fig. 16C). Stem attachment round without flaring basals.

Basals three, normally arranged in a medium-sized cone, making up slightly more than half of pelvis, slightly concave in profile. Two larger and one smaller (azygous) basal; latter in AB interray, 4.0 mm long and 2.5 mm wide; larger basals about same length and about 3.5 mm wide in holotype. Stem facet at tip of cone, nearly round, about 0.8 mm in diameter with a tiny central lumen, secondary deposits very minor around stem facet.

Radials five, elongate, making up most of thecal surface. Each radial has nearly parallel lateral sutures, and most limbs extend nearly to a point at their adoral end. In holotype, radials 7.2 mm long, 2.7 mm maximum width, with body 2.8 mm long and limbs 4.6 mm long along each ambulacrum. Radial body nearly straight in profile, radial limbs slightly curved in profile.

Regular deltoids four, small, not visible on thecal plate surface, strongly overlapped by radials. In holotype, deltoids 0.9 mm long in ambulacral sinus, about 0.2 mm wide, with low crest on summit sloping down to spiracles and deltoid lip. Radiodeltoid suture only slightly raised over ambulacral surface. Spiracles apparently paired, with thin depressed deltoid septum not completely separating spiracles from adjacent ambulacra (Plate 4, Fig. 13).

Anal deltoids poorly exposed or missing from all specimens, should be four in number. Enlarged aboral hypodeltoid exposed on the thecal surface, small adoral superdeltoid, and two hidden cryptodeltoids beneath hypodeltoid. Anispiracle apparently paired also and anus not completely separated from posterior spiracles.

Ambulacra five, narrow, elongate. In holotype, ambulacra about 5.5 mm long, about 0.7–0.8 mm wide along much of length. In separate radials, ambulacral sinus up to 8.0 mm long. Lancet thick, keeled on interior (Text-Fig. 16D), completely covered by side plates, about 10 side plate sets per 3 mm length. Holotype has about 19 side plate sets per ambulacral side, one brachiole facet per side plate set. Sutures between opposing sets of inner side plates in main food groove; small outer side plate notched aboral-abmedial edge of inner side plate (Text-Fig. 16D). One pore per side plate set along radial and short deltoid margins (pores alternate with brachiole facets), short pore furrows indistinct. Side plate sets become smaller (and less oblique) adorally, especially alongside deltoids; side food grooves enter main food groove at 30° angle aborally, nearly 60° angle adorally.

Hydrospires poorly known, apparently at least two and more likely three hydrospires per ambulacral side in paratype MCZ 807. No hydrospire plate present.

Ornament on basals and radials consists of closely spaced growth lines paralleling sutures; best exposed on holotype and nonsilicified separate radials (Plate 4, Figs. 1–2 and 10–11). Secondary deposits nearly lacking from stem facet, only small lip at tip of each ambulacrum at radial origin.

Growth features poorly known because many specimens incompletely preserved; smallest specimen (holotype MCZ 803) 11 mm long, largest specimen (paratype MCZ 806) an estimated 17 mm long (pelvis mostly missing). Measurements for three most complete specimens in Table 4. Stem and brachioles unknown in present material.

Studied Specimens. Holotype MCZ 803, paratypes MCZ 804–810 (five partial specimens and two radial plates).

Occurrence. Known from the lower Lodgepole Limestone at five localities in southwestern Montana: holotype from Antelope Valley 39–45 ft (12–14 m) above the base of the Paine Member, three paratypes from Milligan Canyon East 12–20 ft (3.7–6 m) above the base, one paratype from Milligan Canyon 18–20 ft (5.5–6 m) above the base, one paratype from London Hills about 40 ft (12 m) above the base, and two radial plates in the float from Northeast Baldy Mountain 20–50 ft (6–15 m) above the base.

Etymology. The species is named for Milligan Canyon, southwestern Montana, where four of the six partial specimens were found.

Discussion. Metablastus milliganensis is the seventh species to be described for this genus (see Fay, 1961, pp. 77–82). It can be differentiated from several *Metablastus* species because it does not have flared basals and a triangular stem facet. It differs from the type species *M. lineatus* by being less elongate (much lower L/W ratio), and from *M. bipyramidatus* and *M. varsouviensis* by having the pelvis longer than the vault. At present, *M. milliganensis* is the earliest described species and may have been ancestral to several later species of *Metablastus*, especially *M. lineatus* which occurs in the Burlington Limestone and is the next oldest species.

Family PENTREMITIDAE Orbigny, 1851
Genus MONTANABLASTUS Sprinkle and Gutschick, new genus

Type Species. Montanablastus baldyensis Sprinkle and Gutschick, new species.

Diagnosis. Spiraculate blastoids with an obconical theca, vault usually equal to or slightly longer than pelvis; four spiracles and an anispiracle; two or three hydrospires per ambulacral side, two anal deltoids, hypodeltoid enlarged; regular deltoids smaller but appearing on side of theca, form low crests above depressed summit, normal V-shaped radiodeltoid sutures with radials abutting deltoids (no overlap); ambulacra moderately long but fairly narrow, lancet exposed toward adoral end, one pore per side plate along radial and deltoid margins; hydrospire plate apparently absent; plates ornamented with fine growth lines; brachioles about two and a half times the-

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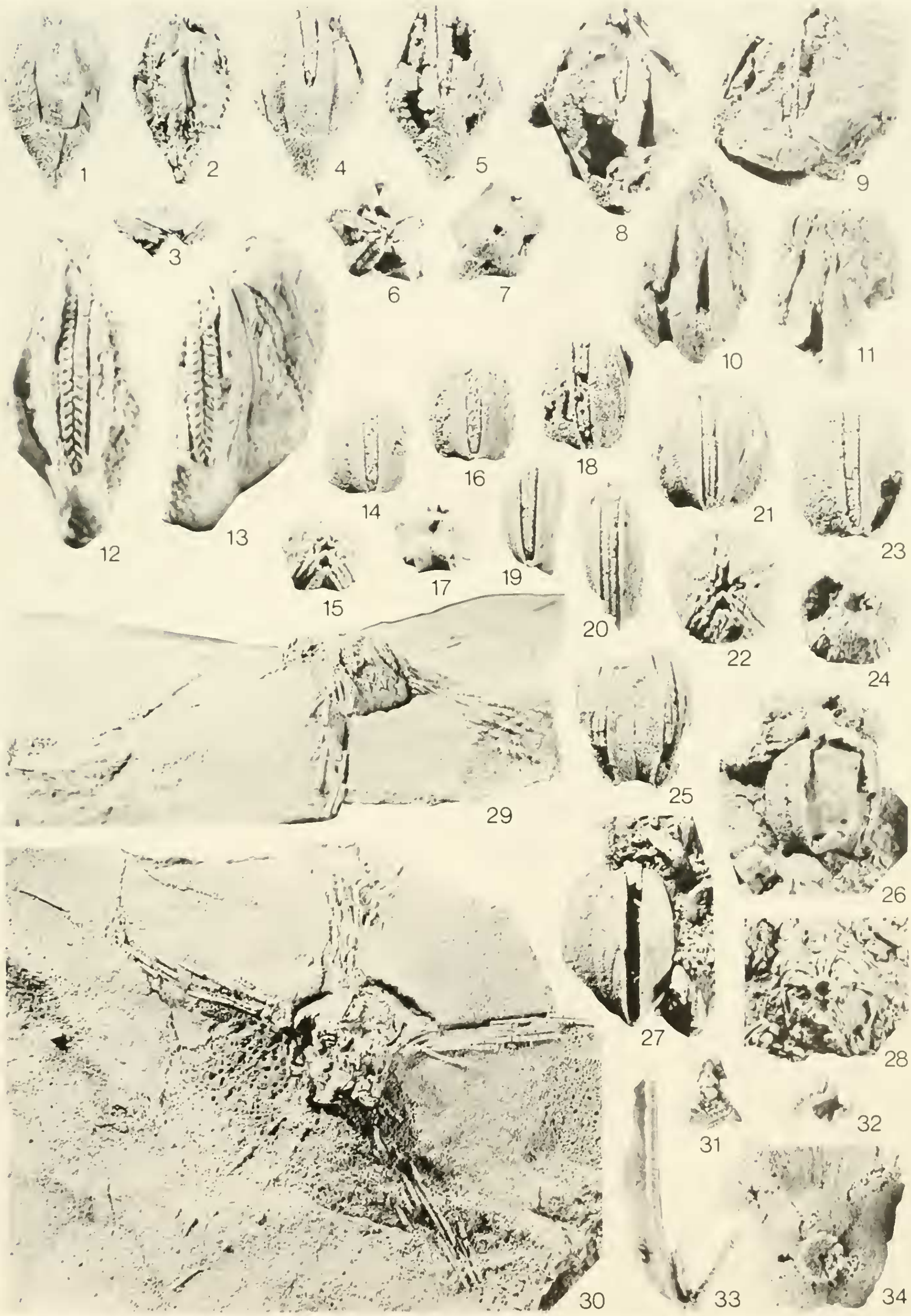
PLATE 4

Figures 1–13. *Metablastus milliganensis* Sprinkle and Gutschick, n. sp., lower Paine Member, lower Lodgepole Limestone, 1–3 and 12–13 from Antelope Valley, 4–7 from Milligan Canyon, 8 from London Hills, 9 from Milligan Canyon East, and 10–11 from Northeast Baldy Mountain, southwestern Montana. 1–3, 12–13, A-side, CD-side, top, and E- and B-ambulacral views, respectively, of relatively small holotype MCZ 803 showing shape of nearly complete but crushed theca and morphology of two well-preserved narrow ambulacra, ×2.6 and ×6.5; 4–7, B-side, D-side, top, and bottom views of medium-sized paratype MCZ 804; note shape, missing tip of basals, and concave interambulacra, ×2.6; 8, side view of large paratype MCZ 805 showing large holes in theca and serpulid (left) attached to radials, ×2.6; 9, side view of very large incomplete paratype MCZ 806 still partly in matrix, ×2.6; 10–11, paratype radials MCZ 809 and 810 showing elongate but relatively narrow ambulacral sinuses, ×2.6.

Figures 14–28. *Cryptoblastus*? sp. A, Woodhurst Member, upper Lodgepole Limestone, Sacagawea Peak, Bridger Range, southwestern Montana. 14–15, C-side and top views of relatively small theca MCZ 1049 showing globular shape and eight closely-set spiracles on summit, ×2.7; 16–17, C-side and bottom views of medium-sized theca MCZ 1045; note long ambulacra and concave basal cavity, ×2.7; 18, side view of medium-sized theca USNM 20670 showing elongate shape and rather coarse silicification, ×2.7; 19, partial radial and ambulacrum MCZ 1051; note side plates and radial ornament, ×2.7; 20, large radial, deltoid, and ambulacrum USNM 20670; note short deltoid at upper right, ×2.7; 21–22, B-side and top views of relatively large globular theca MCZ 1046 showing eight closely-set spiracles on summit, ×2.7; 23–24, C-side and bottom views of large elongate theca MCZ 1047; note long ambulacra and small concave basals, ×2.7; 25, interradial side view of large broken theca MCZ 1050 with fine growth lines, ×2.7; 26, side view of large broken theca MCZ 1055 in etched slab showing disrupted plates at top of theca from horizontal worm burrow, ×2.7; 27, side view of very large broken theca MCZ 1048; note growth lines and long ambulacral sinus, ×2.7; 28, top view of eroded theca MCZ 1053 showing summit features and trace of hydrospires beneath C-ambulacrum, ×2.7.

Figures 29–30. *Cryptoblastus*? sp. C, upper Paine Member, middle Lodgepole Limestone, Northeast Baldy Mountain, Bridger Range, southwestern Montana. Side and bottom views of weathered globular theca MCZ 1040 in slab showing eroded slightly convex base, growth lines on radial (30, upper right), and brachioles radiating from all five long ambulacra, ×2.8.

Figures 31–34. *Cryptoblastus*? sp. B, upper Paine Member, middle Lodgepole Limestone, Bandbox Mountain, west-central Montana. 31, surface view of small deltoid MCZ 1041; note closely-set spiracles, two large spines in center, and growth lines aborally, ×6; 32, edge view of small deltoid MCZ 1042 showing three large spines and trace of hydrospire folds, ×6; 33, radial fragment MCZ 1044 with long ambulacral sinus, ×6; 34, basal set MCZ 1043 with parts of D and E radials; note stem facet on slightly convex basals, growth lines, and large lip at each radial origin, ×6.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cal length; small-diameter stem having slightly flanged columnals.

Occurrence. Early Mississippian (Late Kinderhookian) (=Earliest Carboniferous-Tournaisian), Montana.

Etymology. Named for the state of Montana, where this new genus was discovered.

Discussion. Most of the available specimens of this genus are exceptionally well preserved with attached brachioles and stem; unfortunately, as in most blastoid occurrences preserved like this, it is very difficult to identify these specimens and study their thecal morphology. Several specimens with buried appendages were partly silicified, and the appendages were sacrificed to uncover the theca by acid etching. However, this was only partly successful because of incomplete silicification and small size of the specimens. *Montanablastus* resembles several other genera in the Family Pentremitidae, but cannot easily be assigned to any of them. It differs from *Hyperoblastus, Conuloblastus, Devonoblastus*, and *Eleutheroblastus* (all Devonian genera, see Fay and Wanner, 1968) by apparently having only two anal deltoids plus other differences in thecal shape, deltoids, ambulacra, and the later age. It differs from Early Mississippian genera such as *Petaloblastus* (see Fay, 1962a) by having much narrower ambulacra with less lancet exposure and V-shaped radiodeltoid sutures, from *Pentremoblastus* by having narrower ambulacra and only two anal deltoids, and from early species of *Pentremites* by having narrower ambulacra and smaller but crested deltoids. Specimens of *Montanablastus* show considerable resemblance to *Metablastus* and *Costatoblastus* (see Sprinkle and Gutschick, 1967, table 1), but these have paired spiracles, thus belonging in a different family, plus differently shaped deltoids and thecal ornament.

MONTANABLASTUS BALDYENSIS Sprinkle and Gutschick, new species

Plate 5, Figures 1–8;
Plate 6, Figures 33–43;
Text-Figure 17; Table 4

Diagnosis. Theca obconical, vault usually slightly greater than pelvis; fairly narrow ambulacra, lancet making up only about 25% of ambulacral width; hypodeltoid about one and a half times as long as other deltoid bodies; ornament consists of fine growth lines, large radial prong at tip of ambulacra; columnals slightly flanged.

Description. At least 30 specimens available for study, including holotype MCZ 886, 26 paratypes either etched out from the matrix or on slabs with attached appendages, and several other possible specimens. Theca obconical, pelvis conical, vault truncated conical to parabolic, sum-

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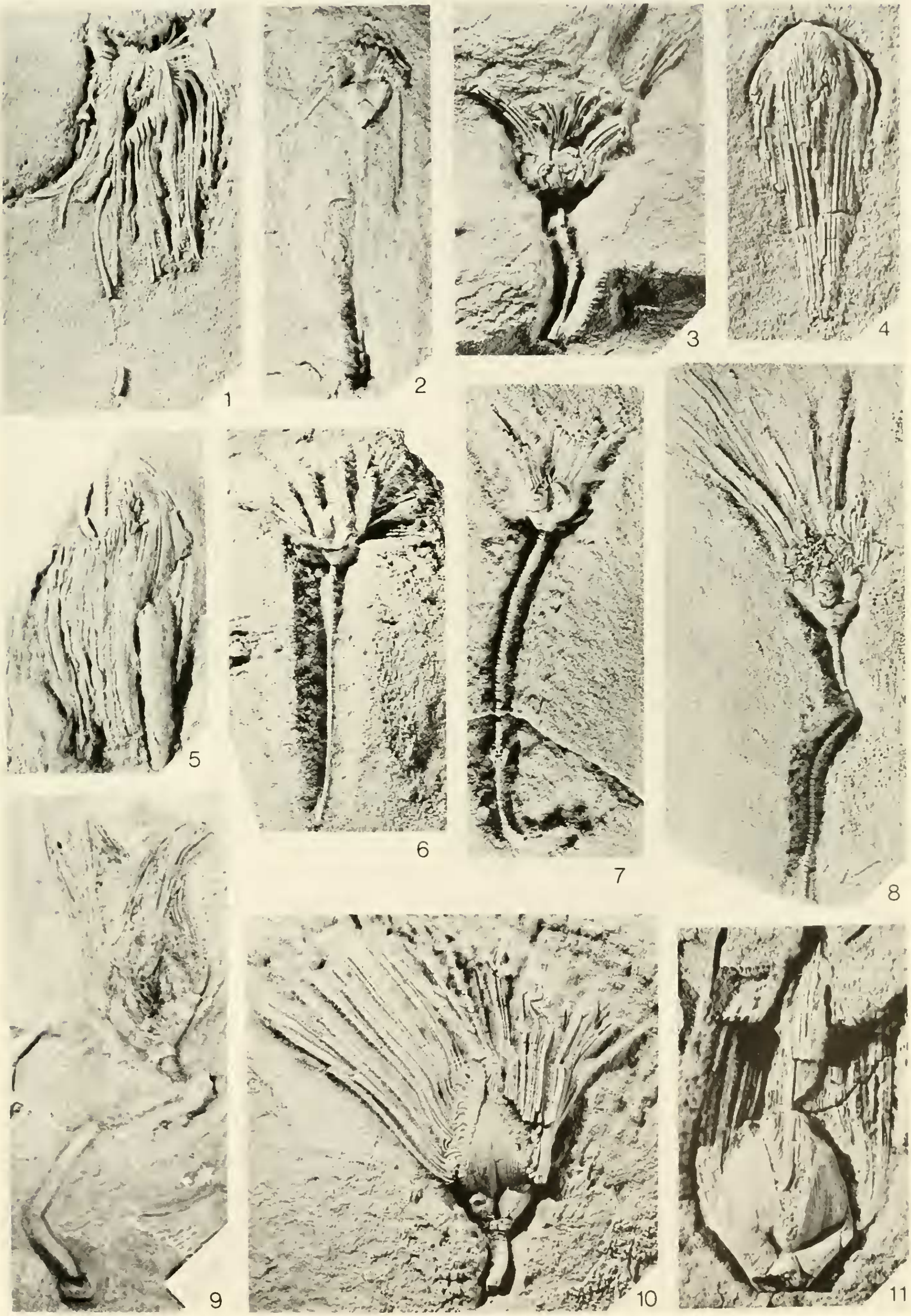
PLATE 5

Figures 1–8. *Montanablastus baldyensis* Sprinkle and Gutschick, n. gen., n. sp., slab specimens from middle Paine Member, middle Lodgepole Limestone, Northeast Baldy Mountain, Bridger Range, southwestern Montana. 1, paratype MCZ 898 showing many long, complete, recurved brachioles, long stem with segment missing, and theca tangled up with Y-shaped ramose bryozoan, ×2; 2, paratype MCZ 903 with crushed theca, few recurved brachioles, and long stem, ×2; 3, paratype MCZ 882 showing many brachioles and deeply-buried stem, ×2; 4, paratype MCZ 900 with tightly-recurved long brachioles hiding most of theca, ×2; 5, paratype MCZ 899 showing long recurved brachioles attached to edges of ambulacra, ×2; 6, paratype MCZ 905 with splayed-out brachioles and deeply-buried stem, ×2; 7, paratype MCZ 901 showing short broken brachioles and long stem with recurved tip, ×2; 8, paratype MCZ 902 with long brachioles and long, deeply-buried, kinked stem emerging from edge of slab (arrow), ×2.

Figures 9–11. *Strongyloblastus laudoni* Sprinkle and Gutschick, n. sp., slab specimens from middle Paine Member, middle Lodgepole Limestone, 9 from Ant Park, Little Belt Mountains, west-central Montana, 10–11 from Northeast Baldy Mountain, Bridger Range, southwestern Montana. 9, paratype MORI 001 (Welch Collection) immersed in water showing badly-crushed theca covered by long brachioles and long, fairly large stem incomplete distally, ×2; 10, paratype MCZ 872 with thecal growth lines, long brachioles attached to edges of ambulacra, and short stem segment, ×2; 11, paratype MCZ 873 showing broken thecal base, small but visible deltoids, and brachioles, ×2.



mit depressed with deltoids projecting above peristome (Text-Fig. 17A). Most specimens fairly small; smallest theca 2.2 mm long, largest theca 10 mm long. L/W ratio ranges from 1.13 to 1.45 and averages 1.32 (10 measurements), gradually increasing with size; V/P ratio ranges from 0.7 to 1.36 and averages 1.02 (eight measurements), showing considerable variation but no obvious trends; and pelvic angle varies from 55° to 75° and averages 69° (eight measurements), gradually increasing with size. Maximum width at large radial lips usually just below midheight; interambulacral areas flat to slightly convex ignoring radial lips, but somewhat concave if radial lips included (Text-Fig. 17B).

Basals three, normally arranged, represent about 50% of pelvis, flat to slightly concave in profile, two larger and one smaller (azygous), azygous basal quadrate, larger basals hexagonal. Stem facet slightly triangular with only small secondary deposits forming platform.

Radials five, large, forming about 50% of pelvis and most of vault, RD axis apparently greater than RB axis at all sizes, large lip up to 0.9 mm long near origin of radials pointing obliquely outward and continuing pelvis profile, lip probably

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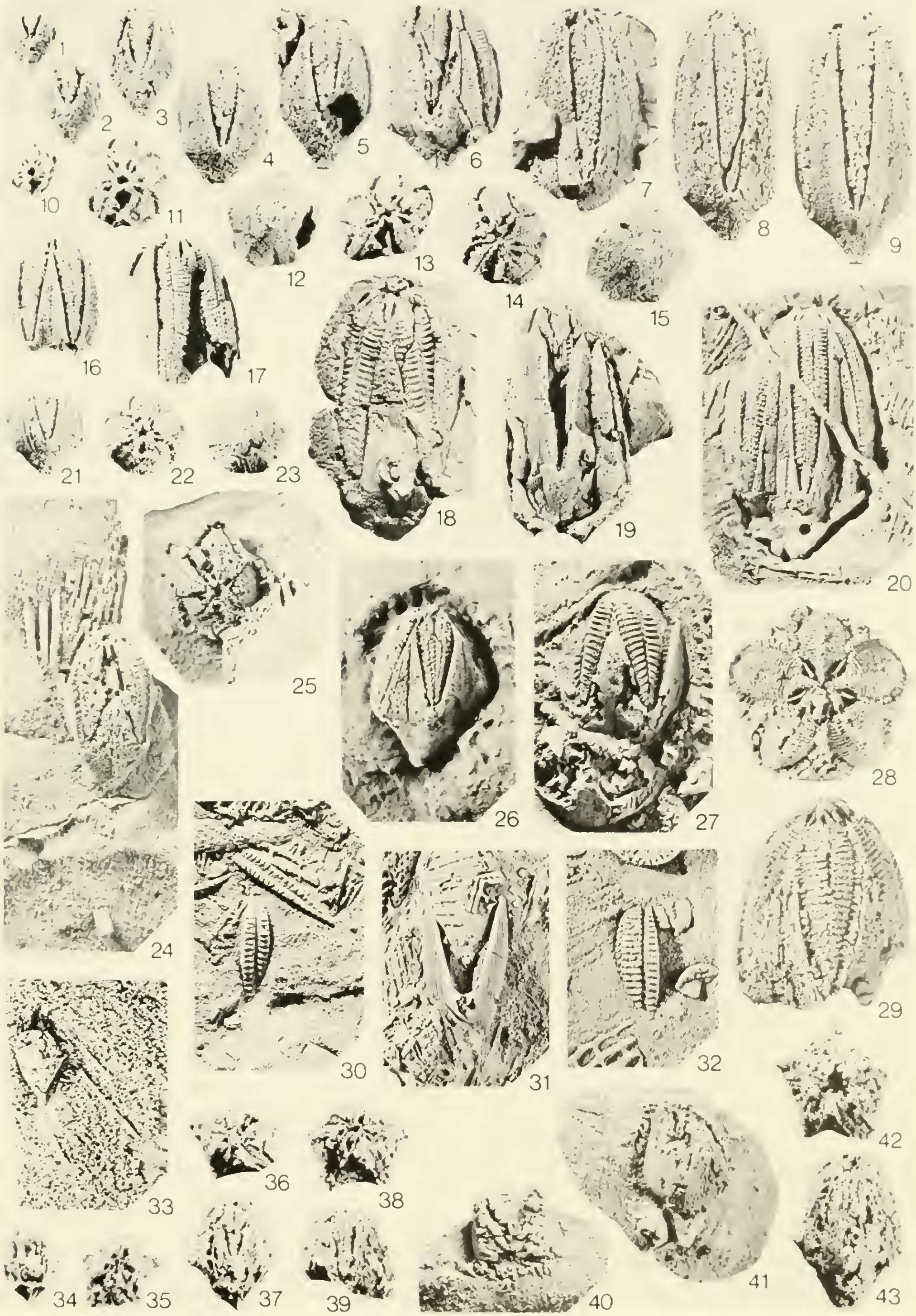
PLATE 6

Figures 1–20. *Strongyloblastus breimeri* Sprinkle and Gutschick, n. sp., lower Paine Member, lower Lodgepole Limestone, 1, 3–5, 9–12, 16, and 19 from Milligan Canyon East, 2, 6, 7, 13, and 17 from Milligan Canyon, 8 and 14–15 from South Boulder, 18 from Dry Hollow, and 20 from Saddle Peak, southwestern Montana. 1, 10, E-side and top views of very small paratype MCZ 843 showing elongate shape, short ambulacra, and separate spiracles, ×2.3; 2, B-side view of small paratype MCZ 844; note vault now longer than pelvis, ×2.3; 3, E-side view of small paratype MCZ 847 showing longer ambulacra and growth lines on radials, ×2.3; 4, 11, D-side and top views of medium paratype MCZ 849; note separate spiracles and damaged base, ×2.3; 5, 12, E-side and bottom views of medium paratype MCZ 851 showing elongate shape and stem facet, ×2.3; 6, B-side view of crushed paratype MCZ 853; note deltoid length and growth lines on radial, ×2.1; 7, C-side view of large paratype MCZ 855 still partly enclosed in matrix, ×2.1; 8, 14–15, D-side, top, and bottom views of large holotype MCZ 841 showing elongate theca with vault much longer than pelvis, separate spiracles on summit, and secondary deposits around stem facet, 2.1; 9, B-side view of very large paratype MCZ 857; note very long, wide ambulacra and deltoid bodies ending well below summit, ×2.1; 13, top view of medium paratype MCZ 860 showing separate spiracles and C-spiracle partly cut off from rest of anispiracle, ×2.3; 16, AB-side view of medium paratype MCZ 862 with rounded summit, ×2.1; 17, C-side view of very large broken paratype MCZ 861 showing enlarged hypodeltoid (top left) and separate spiracles, ×2.1; 18, oblique EA-side view of medium paratype MCZ 854 still partly in matrix; note well-preserved ambulacra showing brachiole facets plus lobes and sockets, and epideltoid (top rear) somewhat larger than other deltoid lips, ×3; 19, side view of large crushed paratype MCZ 866 missing most of the ambulacra but having well-preserved growth lines on the radials, ×2.3; 20, side view of very large crushed paratype MCZ 859 in slab showing long wide ambulacra, visible deltoids, and separate spiracles, ×2.1.

Figures 21–23. *Strongyloblastus* sp., lower Paine Member, lower Lodgepole Limestone, Targhee Peak, southeastern Idaho; A-side, top, and bottom views of small but well-preserved theca MCZ 870 showing different shape from 1–3 above, separate spiracles with C-spiracle cut off from rest of anispiracle (22), and growth lines on radials, ×2.5.

Figures 24–32. *Strongyloblastus laudoni* Sprinkle and Gutschick, n. sp., upper Paine Member, middle Lodgepole Limestone, Northeast Baldy Mountain, Bridger Range, southwestern Montana. 24–25, oblique EA-side and top views of medium paratype MCZ 874 partly etched from matrix; note wide ambulacra, separate spiracles, silicified brachioles from back ambulacra, and stem emerging from matrix (24, bottom), ×3; 26, side view of medium paratype MCZ 875 showing short but visible deltoids and lancet in center of ambulacrum, ×2.9; 27, side view of medium paratype MCZ 878; note well-preserved ambulacra with brachiole facets and pore furrows, ×3; 28–29, top and D-side views of large silicified but broken holotype MCZ 871 showing separate spiracles, thin septum barely cutting off C spiracle from rest of anispiracle, wide ambulacra with brachiole bases still attached to some facets, and cover plates over proximal ambulacra and mouth, ×3; 30, two wide lancet plates (paratype MCZ 881) on a slab, ×3; 31, radial plate (paratype MCZ 879) with wide sinus and well-developed growth lines, ×3; 32, lancet with partial side plates (paratype MCZ 880) showing lancet width and brachiole facets (left), ×3.

Figures 33–43. *Montanablastus baldyensis* Sprinkle and Gutschick, n. gen., n. sp., upper Paine Member, middle Lodgepole Limestone, Northeast Baldy Mountain, Bridger Range, southwestern Montana. 33, very small weathered paratype MCZ 909 in slab; note attached stem segment and two adjacent brachioles, ×3; 34, side view of small silicified paratype MCZ 891 showing exposed plate sutures, ×3; 35, 37, top and C-side views of medium silicified paratype MCZ 889; note four spiracles plus anispiracle (35), plate sutures, and large radial lips, ×3; 36, 39, top and A?-side views of medium paratype MCZ 888 showing deltoids, traces of oral cover plates, and fairly narrow ambulacra, ×3; 38, top view of medium silicified paratype MCZ 887; note four spiracles and epideltoid bordering anispiracle, ×3; 40–41, top and side views of medium silicified paratype MCZ 893 in slab showing thecal shape and many brachiole segments, ×3; 42–43, top and E-side views of fairly large silicified holotype MCZ 886 showing thecal shape, relatively narrow ambulacra, and large radial lips, ×3.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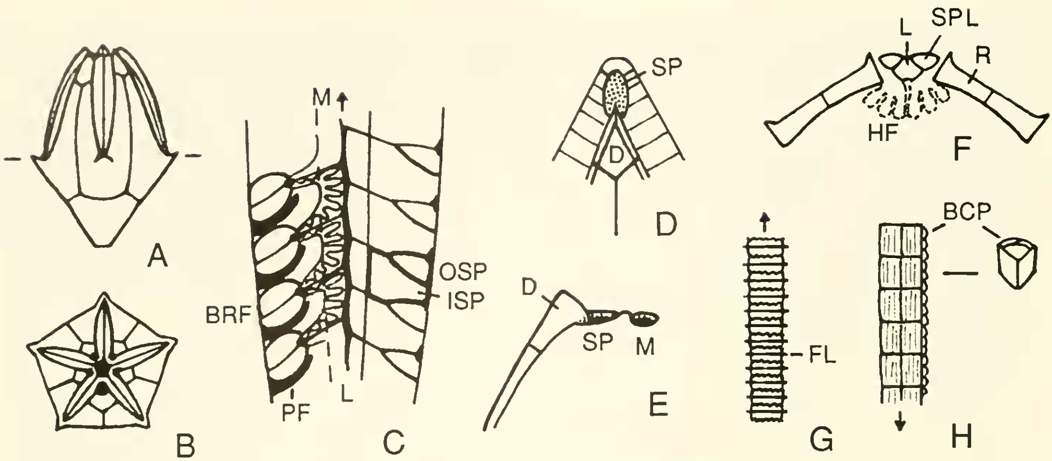


Text-Figure 17. Morphology of *Montanablastus baldyensis*, n. gen., n. sp. A–B, side and summit views of large theca based on paratype MCZ 889 and holotype MCZ 886; note shape, location of maximum width just below midheight (short lines), and summit features. C, much-enlarged plan view of ambulacrum in paratype MCZ 896 showing lancet (L) exposed in center, large inner and small wedge-shaped outer side plates (ISP and OSP) together supporting a hemi-elliptical brachiolar facet (BRF), pore furrow (PF) curving around lower edge of facet, and cover plate lobes and sockets. D–E, much-enlarged plan and side views of spiracle (SP) and mouth (M) on depressed summit with adjacent raised deltoid (D) and adoral ambulacra; based mostly on paratypes MCZ 886 and 887. F, enlarged cross section through adoral theca in paratype MCZ 895 showing ambulacrum made up of lancet (L) and side plates (SPL), adjacent radial limbs (R) with raised edges, and apparently three, poorly preserved, silicified hydrospire folds (HF) on each side, ×8.6. G, proximal stem in paratype MCZ 898 showing columnal shape and thin flange (FL) around center; arrow points to attachment at base of theca, ×17.2. H, side view and cross section of brachiole in paratypes MCZ 898 and 905; note striations on side and low biserial set of cover plates (BCP) over relatively deep, V-shaped, food groove; arrow points to attachment on ambulacrum, ×21.5.

formed from secondary deposits, but one theca has lip with closely spaced growth lines.

Regular deltoids four, small, body triangular, extends only short distance down thecal surface but visible in side view, V-shaped suture between radials and deltoid forming 80–85° angle, deltoids slightly concave in profile, radials abut deltoids without obvious overlap. In several thecae, deltoids 0.8–0.9 mm long, projecting above nearly flat summit (Plate 6, Figs. 36–39), sharp adoral edge of deltoids dropping away rapidly to below summit level; four spiracles formed in front of projecting deltoid bodies by edges of ambulacra and curved deltoid lips, spiracles teardrop-shaped, small, with depressed deltoid septum not reaching surface (Text-Figs. 17D–E).

Anal deltoids apparently two, somewhat enlarged hypodeltoid aborally, 1.2–1.5 mm long (about one and a half times length of regular deltoids), slightly ridged with stronger growth lines; epideltoid small, separates mouth from anispiracle, depressed aboral side has three troughs for central anus and two lateral hydrospire groups (Plate 6, Fig. 38), septa separating these troughs depressed to form true anispiracle, no evidence of cryptodeltoids.

Ambulacra five, moderately long, fairly narrow, slightly convex in cross section, lancet partly exposed in center of adoral half, forming about 25% of ambulacral width, side plates on bevelled abmedial edges of lancet, appear to be normally arranged but not well preserved or exposed in most specimens, 14 side plate sets present in one ambulacrum 4.0 mm long, side food grooves meet main food groove at 45–60° angle, inner side plates apparently large, rectangular, outer side plates not obvious but probably small triangular wedges underlying half of brachiole facets, brachiole facets large, at slight angle to side food grooves, occupy about half of ambulacral width (Text-Fig. 17C). Main food groove has 4–5 lobes between each pair of side food grooves, which have about three smaller lobes on the adoral and aboral sides.

Hydrospires in 10 groups, apparently 2–3 folds per ambulacral side based on two poorly preserved silicified specimens and a sectioned slab specimen (Text-Fig. 17F).

Ornament consists of fine growth lines on basals and radials, somewhat coarser growth lines on deltoids, hypodeltoid and radial-hypodeltoid growth front.

Nearly two-thirds of specimens have brachioles preserved and nearly half have proximal stem attached; complete brachioles about 15–16 mm long in 6 mm long theca (Plate 5, Fig. 1) with rounded triangular cross section, biserial brachiolar plates (BP), and one low set of tiny biserial cover plates (BCP) often pyritized along with wide V-shaped brachiolar food groove (Text-Fig. 17H). Brachiolar plates about 0.2 mm long, 0.25 mm wide, with a very small central ridge and fine striations extending down length (Text-Fig. 17H); about two BCP/BP where observable. Stems incomplete, ranging up to 29 mm long (attached to theca 5.5 mm long; Plate 5, Fig. 7); this stem has about 190 columnals in this length. Columnals having rounded edges and small equatorial flange, a tiny central lumen, and averaging 0.14–0.15 mm long, 0.5 mm wide proximally, and 0.3 mm (or 0.35 mm with flanges) wide distally (Text-Fig. 17G).

Growth information for the few measurable specimens summarized in Table 4.

Studied Specimens. Holotype MCZ 886, paratypes MCZ 882, 887–913, additional specimens MCZ 914.

Occurrence. All described specimens come from the Northeast Baldy Mountain locality in the southern Bridger Range of southwestern Montana. Specimens occur in series of beds with 6–8 in. (0.15–0.20 m) of limestone interbedded with shaly dolomite from the middle Paine Member between 150 and 175 ft (46–53 m) above the base of this member.

Etymology. Named for the Northeast Baldy Mountain locality where all the studied specimens were collected.

Discussion. Montanablastus baldyensis is an unusual blastoid for the Early Mississippian. The fairly narrow ambulacra are not particularly similar to other forms in the Family Pentremitidae; even species such as *Pentremites conoideus* have wider ambulacra with more lancet exposure. The radial lips are very large for a blastoid, continue the profile from the pelvis, and the lip on one specimen shows apparent growth lines, indicating that the lips were produced by periodic small increments of growth and not by secondary deposits. Many specimens with appendages are excellently preserved and were cleaned with an air abrasive unit, but are almost useless for trying to work out the thecal morphology of this species. More and better silicified materials will be necessary before more complete information can be obtained.

Family PENTREMITIDAE? Orbigny, 1851
Genus STRONGYLOBLASTUS Fay, 1962b

Type Species. Strongyloblastus petalus Fay, 1962b.

Diagnosis. Spiraculate blastoids with an ovoid, ellipsoidal, or obconical theca; eight divided spiracles plus variable arrangement on anal side (anispiracle, "C" spiracle plus half-paired anispiracle, or "C" and "D" spiracles plus anus); 3–5 hydrospire folds per ambulacral side; two anal deltoids, prominent epideltoid often larger and higher than other deltoid lips, and hypodeltoid with slightly enlarged body and adorally projecting septum more prominent than those of other deltoids; regular deltoids appear on side of theca, deltoid body short to moderately long, sometimes heavily ridged, radials overlap deltoids; ambulacra medium to long, very wide, lancet completely exposed, occupying 40–60% of ambulacral width, one pore per side plate along radials, pores either present along deltoids or closed off short distance above radiodeltoid suture, no hydrospire plate present; ornament consisting of fine to coarse growth lines.

Occurrence. Early to Middle Mississippian (Early Carboniferous), southern Canadian Rockies, northern U.S. Rockies, Mississippi Valley, and Alaska.

Discussion. Two new species of *Strongyloblastus* occur in the Lodgepole Limestone in southwestern Montana, one in the lower Paine Member and the second in the upper Paine Member. A single additional specimen from the lower Paine Member is unassigned at present. A third new species belonging either to *Strongyloblastus* or to *Pentremites* (as presently defined) occurs in the younger Castle Reef Dolomite in the Sun River Canyon area of northwestern Montana; this form will be described in a separate paper.

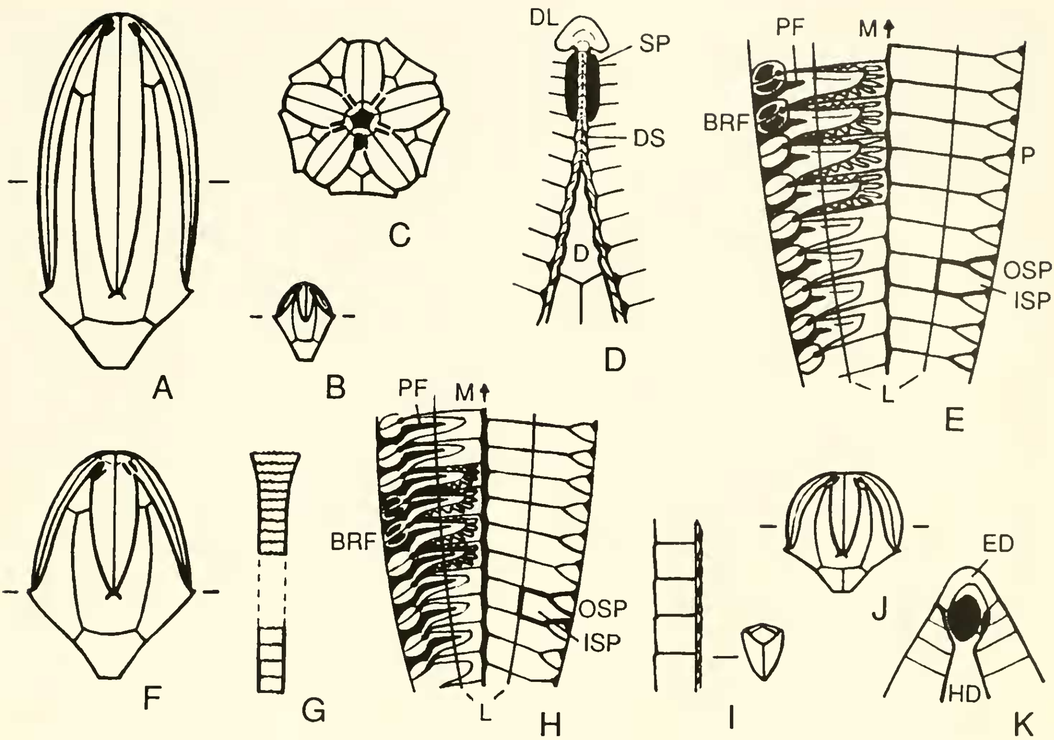
Strongyloblastus was described by Fay (1962b) as a Devonian blastoid from western New York State, based on the label that accompanied the holotype specimen. Macurda and Breimer (1977, p. 693) reported that "*Strongyloblastus* was completely anomalous when compared with other Devonian blastoids," and that similar specimens occur in the Banff Formation of Early Mississippian (probably Late Kinderhookian) age in the southern Canadian Rockies, and concluded that the label with the holotype was incorrect. Occurrences of similar blastoids belonging to different species are known from the northern U.S. Rockies (see following) and from Alaska. Fay (1964) assigned *Strongyloblastus* to the Family Schizoblastidae, but Macurda and Breimer (1977, p. 694) assigned it to the Family Pentremitidae after some discussion because of its overall resemblance to several early species of *Pentremites*, although this family then cannot be characterized alone by having four spiracles and an undivided anispiracle.

Strongyloblastus is most closely related to several early species of *Pentremites* with divided spiracles, such as *P. elongatus* and *P. kirki* (Macurda, 1975; Horowitz, Waters, and Macurda, 1981; Horowitz, Macurda, and Waters, 1986). *Strongyloblastus* differs only slightly from *Pentremites* species having divided spiracles (see Macurda and Breimer, 1977, p. 696) by having nonfunctional ambulacral pores along most of the deltoid margin and higher septa separating the anus from one or both of the posterior spiracles. These differences are very minor and intermediate stages occur in some of the new species described here, in contrast to the difference between divided and undivided spiracles, a difference that previously would have placed these blastoids in different families (see Fay, 1964; Fay and Wanner, 1968).

Instead of having these two genera separated by such minor differences at present, we propose that all species with divided spiracles now assigned to or inferred to belong to *Pentremites* (*P. elongatus*, *P. kirki*, and one or more undescribed species from Montana, western Canada, and Alaska) be assigned to the genus *Strongyloblastus* Fay (1962b). This proposed change would restrict *Pentremites* to species having undivided spiracles (like its type species *P. godoni*), remove two named and described species from the genus, and restrict its range to Middle Mississippian (Meramecian) to Early Pennsylvanian (Morrowan). *Strongyloblastus* would range throughout much of the Early Mississippian from the late Kinderhookian in the Rocky Mountains (Lodgepole Limestone, Banff Formation) to at least the late Osagean in the Midwest (Burlington Limestone) and perhaps higher in the Rocky Mountains. *Strongyloblastus* may have been ancestral to *Pentremites* by suppression of the deltoid septa in the regular spiracles and anispiracle, retention of functional pores along the deltoid margins, and perhaps enlargement of the deltoid body.

STRONGYLOBLASTUS BREIMERI
Sprinkle and Gutschick, new species
Plate 1, Figures 4–5;
Plate 6, Figures 1–20;
Text-Figures 18A–E and 19

Diagnosis. Theca changing from obconical to elongate ellipsoidal during growth, L/W ratio averages 1.61, V/P ratio av-



Text-Figure 18. Morphology of *Strongyloblastus breimeri*, n. sp. (A–E), *S. laudoni*, n. sp. (F–I), and *S.* sp. (J–K). A–C, enlarged side views of large paratype theca MCZ 857 and small paratype theca MCZ 843 and summit view of large theca showing considerable change in shape between biconical juvenile and ellipsoidal adult, very long and wide ambulacra, separate spiracles and half-paired anispiracle on summit, and short lines at maximum width. D, much-enlarged deltoid body (D), thin deltoid septum (DS) separating elliptical spiracles (SP), and deltoid lip (DL) separating spiracles from mouth in paratype MCZ 854, ×8.6. E, plan view of ambulacrum in MCZ 854 showing wide exposure of lancet (L) in center, large inner and small triangular outer side plates (ISP and OSP) supporting a brachiole facet (BRF) at the ambulacral edge, curved pore furrow (PF) extending from pore (P) toward center of ambulacrum, and numerous cover plate lobes and sockets, ×14.6. F, side view of paratype theca MCZ 875 showing different shape and shorter ambulacra from A above (maximum width at short lines), ×2.1. G, proximal and medial stem in MORI 001; note enlarged proximal stem with thin columnals just below attachment and lack of flanges on columnals, ×3.4. H, plan view of ambulacrum in MCZ 878 showing lancet (L) exposed in center, inner and outer side plates (ISP and OSP), brachiole facets (BRF) at ends of side food grooves, and somewhat longer pore furrows (PF) just reaching lancet, ×3.9. I, much-enlarged side view and cross section of brachiole in MCZ 872; note smooth brachiolar plates and cover plates over shallow food groove, ×12. J, side view of small theca MCZ 870 showing difference in shape from B above (short lines at maximum width), ×3.2. K, enlargement of anal side in MCZ 870 showing epideltoid (ED) septum cutting off C spiracle from rest of anispiracle and reaching hypodeltoid (HD), ×7.6.

erages 2.29, pelvic angle averages 82°, interambulacra slightly concave; ambulacra long, moderately to strongly convex, lancet fully exposed, occupying about 50% of ambulacral width; one pore per side plate set along radials, pores absent just above radiodeltoid suture because of ridges on edge of deltoid; eight spiracles and a half-paired anispiracle on summit, one epideltoid limb partly separates "C" spiracle, "D" spiracle and anus not separated; deltoids fairly long but body on thecal surface short except for enlarged hypodeltoid, surface of deltoids not ridged; three hydrospire folds per ambulacral side.

Description. Forty-seven specimens and fragments available for study; description based on holotype MCZ 841, 17 additional nearly complete paratypes in growth series, and 10 other specimens and fragments. Theca obconical in small specimens changing to ellipsoidal in medium to large ones (Text-Figs. 18A–B); in adults, theca made up mostly of long parabolic vault with a short conical pelvis. Growth series specimens range from 3.9 mm long to 22.9 mm long, holotype a large, slightly compressed theca 18.6 mm long (Plate 6, Figs. 8, 14–15). In 18-specimen growth series, L/W ratio ranges from 1.30 to 2.24 and averages 1.61, increasing gradually above a length of 15 mm; V/P ratio ranges from 0.96 to 3.88 and averages 2.29, increasing dramatically throughout growth; and pelvic angle ranges from 65° to 95° and averages 82°, increasing in small specimens up to about 9 mm long. Greatest width near midheight in large specimens, at or just above tips of ambulacra in small thecae (Text-Figs. 18A–B). Pelvis profile slightly concave, interambulacra slightly concave near midheight, ambulacra moderately to strongly convex all along length, edges slightly depressed below adjacent thecal plate surfaces.

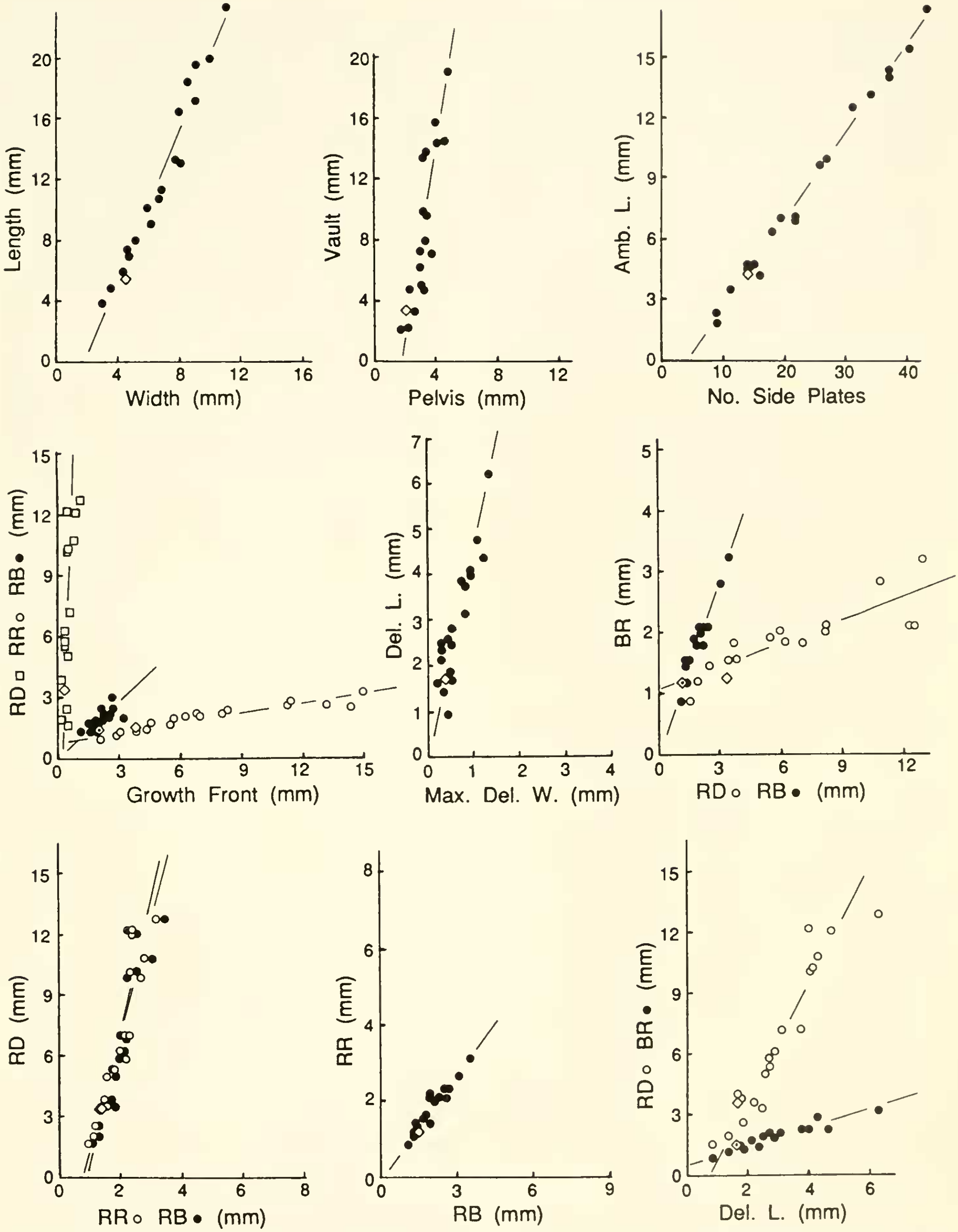
Basals three, normally arranged, forming about half of pelvis; two larger, one smaller (azygous), azygous basal quadrate, 2.4 mm long and 1.9 mm wide in medium-sized specimen; larger basals hexagonal, about same length, approximately 2.9 mm wide (somewhat distorted); stem facet relatively large, up to 1.7 mm in diameter with slight ridge around periphery and small central lumen about 0.2 mm in diameter, facet on raised platform of secondary deposits covering origin of basals.

Radials five, very long, making up most of thecal surface, RD axis slightly greater than RB axis in smallest specimens, many times greater in largest ones (Text-Fig. 19), RD and RHD fronts nearly straight, radials overlap deltoids along short suture, radial limbs raised along ambulacral margins (slight secondary deposits on surface) but edges not grooved here, small wide lip at radial origin pointing laterally.

Regular deltoids four, body short and narrow, above level of adjacent ambulacra, septum and lip long and narrow, at or just above level of ambulacra (Text-Fig. 18D). Deltoid lip triangular, notched by spiracles aborally; septum long, about 0.4 mm wide, relatively sharp, separates spiracles and adjacent ambulacra, grooved on edges facing spiracles; deltoid body triangular, flat to slightly concave, nearly smooth on surface, edges grooved at each brachiole facet on ambulacrum (Text-Fig. 18D), with a slightly M-shaped DR suture making an angle ranging from 60° to 140° in different specimens; radials strongly overlap deltoids at surface but suture becomes nearly vertical at level of ambulacra. In paratype MCZ 854 (Plate 6, Fig. 18), total deltoid length 4.2 mm with body 1.6 mm long and 0.7 mm wide, septum about 1.8 mm long and 0.35 mm wide between spiracles, and lip 0.8 mm long and 1.0 mm wide.

Anal deltoids two, slightly enlarged epideltoid adorally and enlarged hypodeltoid aborally. Epideltoid triangular to inverted U-shaped, slightly wider than other deltoid lips, extends higher above mouth, notched aborally by "C" spiracle (cut off by low epideltoid septum) and half-paired anispiracle (Plate 1, Fig. 5). Hypodeltoid enlarged over other deltoids, body extends about 1 mm further down theca in several large specimens, nearly 1.6 times size of other deltoids in one fragment (4.2 vs. 2.6 mm; Plate 6, Fig. 17), hypodeltoid septum wider and higher than other deltoid septa, extending up to form raised hood over aboral edge of half-paired anispiracle (Plate 1, Fig. 5), right edge meets raised septum from epideltoid cutting off "C" spiracle. Half-paired anispiracle slightly asymmetric, elliptical, slightly larger than mouth; "C" spiracle elongate, slightly smaller than other spiracles.

Ambulacra five, long, very wide, strongly convex aborally to moderately convex adorally, about 15 mm long in holotype, about 2.5 mm wide at widest point; lancet completely exposed in center, occupies about 50% of ambulacral width, fairly thin in cross section; side plates on bevelled edge of lancet, inner side plates medium-sized, wide, nearly rectangular, outer side plate small, triangular, on aboral-abmedial edge



Text-Figure 19. Growth plots for 19 measured specimens (MCZ 841–859) of *Strongyloblastus breimeri*, n. sp., plus single small specimen (MCZ 870) of *S.* sp. (white or dotted diamond). Note large size range and nearly equal RR and RB growth vs. much faster RD growth. Best-fit lines in all plots were hand fit.

of inner side plates, each side plate set forms one brachiole facet at edge of ambulacrum (Text-Fig. 18E). Main food groove extending down center of each ambulacrum, between side food grooves having about four lobes on each side formed by lancet; side food grooves long, empty into main food groove at 50–85° angle, each has 5–6 lobes on adoral side, 3–4 cryptic lobes aborally (formed by lancet and inner side plate), large brachiolar pit at end of side food groove; brachiole facets well developed, elliptical, tilted about 30–40° to side food groove, closely spaced, made up of two shallow depressions. One pore per side plate set along radials, alternating with brachiole facets along smooth radial edge, short to medium-length pore furrow extending in from pore between brachiole facets almost to lancet; pores apparently absent from deltoid margin just above radiodeltoid suture because deltoid edge grooved (at each brachiole facet) and vertical deltoid ridge between grooves extends into apparent pore position at edge of ambulacrum.

Hydrospire groups 10, extend short distance into coelomic cavity from ambulacrum sides, three hydrospires per group (poorly preserved in three specimens), short slit and enlarged tube at bottom of each hydrospire, no hydrospire plate present.

Ornament consists of medium to strong growth lines parallel to plate sutures on basals and radials, fine growth lines on deltoids (Plate 6, Figs. 19–20), chevrons on radial limbs below enlarged hypodeltoid somewhat coarser than other growth lines, deltoids not coarsely ridged so far as known.

Measurements of specimens in growth series plotted in Text-Figure 19.

Stem, brachioles, and cover plates unknown.

Studied Specimens. Holotype MCZ 841, paratypes MCZ 842–868 (27 specimens and fragments), and MCZ 869 (19 additional partial specimens and fragments).

Occurrence. Known from the lower Lodgepole Limestone at six localities in southwestern Montana; 21 specimens from Milligan Canyon East 12–20 ft (3.7–6 m) above the base of the Paine Member, 20 specimens and fragments from Milligan Canyon 20–25 ft (6–7.5 m) above the base, the holotype and one other specimen from South Boulder Canyon in the float from beds about 40 ft (12 m) above the base, and single specimens from Dry Hollow 30–35 ft (9–11 m) above the base, from the talus piles at Standard Creek from beds 15–54 ft (4.5–16.5 m) above the base, and from Saddle Peak 55–60 ft (17–18 m) above the base.

Etymology. Named for Albert Breimer, State Museum of Geology and Mineralogy, Leiden, Netherlands, one of the authors who restudied the type species *Strongyloblastus petalus* and corrected its age and occurrence and re-evaluated its phylogenetic position.

Discussion. Strongyloblastus breimeri is somewhat intermediate in its morphology between *S. petalus*, the type species, and "*Pentremites*" *elongatus*, perhaps an argument for assigning all three of these species to the same genus. It resembles *S. petalus* by having a half-paired anispiracle (see below), the epideltoid and hypodeltoid raised and somewhat enlarged, by having the pores closed off along much of the deltoid margin, by having smooth radial edges vs. ridged deltoid edges, and by being almost the same age (Late Kinderhookian). It resembles "*P.*" *elongatus* in its general theca shape, by having three hydrospire folds per ambulacral side, by having nearly smooth deltoid bodies, and by having the hypodeltoid somewhat enlarged over the regular deltoids. It differs from both of these species by having a somewhat different thecal shape, much shorter deltoid bodies, and the "C" spiracle just barely separated from the half-paired anispiracle.

An excellently preserved vault of *S. petalus* from the Spreng Collection, University of Missouri, Rolla (UMR 6967; Plate 1, Figs. 6–7), shows the anispiracle and summit better than any of the specimens figured by Macurda and Breimer (1977, plate 1). It definitely has a half-paired anispiracle similar to but more strongly developed than in *S. breimeri*, with the epideltoid limb separating the "C" spiracle much wider and somewhat higher (Plate 1, Fig. 7). Apparently the epideltoid limbs have variable development in *S. petalus*, with some specimens having a half-paired anispiracle and others having an anus and two separate spiracles on the posterior side. In the Spreng Collection specimen of *S. petalus*, the epideltoid is horseshoe-shaped, much larger and higher than the regular deltoid lips, and produces a mouth that is much wider than high, plus four ambulacra ("B"–"E") that are curved on the summit (Plate 1, Fig. 7), both rather unusual features for a blastoid.

The critical specimen of *S. breimeri* for showing the half-paired anispiracle was taken out of the acetic acid bath at the Indiana University Field Station in southwestern Montana just after the summit and adoral ambulacra were exposed (see Plate 1, Fig. 5), and brought back to Harvard University to be photographed. After being coated with Glyptal, it was put in acid again to extract the rest of the specimen from the matrix; unfortunately, nearly all the earlier summit detail was destroyed by later acid etching (see Plate 6, Fig. 11). Later specimens from the Milligan Canyon localities showing excellent detail during acid etching were removed permanently, even if incompletely exposed.

STRONGYLOBLASTUS LAUDONI
Sprinkle and Gutschick, new species
Plate 1, Figure 3; Plate 5, Figures 9–11; Plate 6, Figures 24–29; Text-Figures 18F–I and 20

Diagnosis. Theca obconical, L/W ratio averages 1.46, V/P ratio averages 1.25, pelvic angle averages 73°, interambulacra flat to slightly convex; ambulacra moderately long, very wide, slightly to moderately convex, lancet fully exposed, occupying 40–50% of ambulacral width; one pore per side plate along radials, pores apparently filled in just above radiodeltoid suture; deltoid body relatively short, crest long, usually depressed below edges of adjacent ambulacra, eight spiracles and a half-paired anispiracle on summit, "C" spiracles barely split off from anispiracle, hypodeltoid not enlarged; three? hydrospire folds per ambulacral side.

Description. Approximately nine specimens and 14 plates available for study, including partly complete, etched holotype MCZ 871, four paratypes in slabs with brachioles and (in three cases) stems preserved, four paratypes in slabs without appendages, and three separate plate paratypes. Theca obconical, changing only slightly in shape during growth through preserved size range, made up of moderately long parabolic vault and moderately short conical pelvis (Text-Fig. 18F). Complete specimens range from about 5.0 mm long to about 14.5 mm long. Holotype a large, well-preserved, incomplete theca etched from slab; as preserved, about 12.0 mm long with complete vault 9.8 mm long and upper part of broken pelvis; original length estimated at 15–16 mm (Plate 6, Fig. 29). Greatest width 9.5 mm just above radial lips, just below apparent midpoint of theca. Interambulacra here flat to slightly convex. In six measurable specimens, L/W ratio ranges from 1.09 to 1.86, averaging 1.46; V/P ratio ranges from 1.25 to 2.11 and averages 1.56; and pelvic angle ranges from 60° to 80°, averaging 73°. Pelvis profile slightly concave, ambulacra slightly to moderately convex.

Basals three, normally arranged, incompletely exposed (or missing) in most specimens, forming about 50% of pelvis, two larger, one smaller (azygous), regular basals hexagonal, about 3.6 mm long and at least 3.5 mm wide in a large specimen; stem facet in this specimen about 1.4 mm in diameter with secondary deposits forming rounded to slightly triangular platform for stem attachment.

Radials five, long, making up most of thecal surface, RD axis greater than RB axis in all available specimens, many times greater in large specimens (Text-Fig. 20), RD front nearly straight, relatively short; small wide lip at radial origin pointing laterally.

Regular deltoids four, body short to medium in length, fairly narrow in most specimens, septum and lip long and narrow, in some specimens septum below level of ambulacra so that side plates from adjacent ambulacra in contact (Plate 6, Fig. 28). Deltoid body 2.5–3.3 mm long, 1.0–1.8 mm wide in large specimens, much smaller in small specimens; septum and lip at least 2.5 mm long, just barely splitting spiracles at surface of summit, septum sharp-crested, part above surface of ambulacrum somewhat ridged, radiodeltoid suture makes angle between 90° and 120° in different specimens, radials moderately overlap deltoids with about 60° angle from plate surface.

Anal deltoids two, hypodeltoid apparently not enlarged over other deltoids. Epideltoid triangular, slightly wider than other deltoid lips, sends thin septum aborally to cut off "C" spiracle from rest of half-paired anispiracle, anus and "D" spiracle apparently not separated (Plate 6, Fig. 28). Hypodeltoid relatively long, body similar to other deltoids but septum higher and not depressed below adjacent ambulacra, may project slightly at aboral edge of anispiracle, which is elliptical except for slightly flattened side along "C" spiracle septum. "C" spiracle similar in size and shape to other spiracles.

Ambulacra five, moderately long, very wide, slightly to moderately convex in cross section, in holotype, about 10.5 mm long, 3.3. mm maximum width; lancet completely exposed in center, occupies between 40 and 50% of ambulacral width, about 0.3–0.5 mm thick in several ambulacral fragments, side plates abutting edge of lancet, suture nearly vertical everywhere except near aboral end of ambulacrum where lancet somewhat bevelled, inner side plates medium-sized, wide, nearly rectangular, outer side plates small, rounded triangular, located on aboral-abmedial edge of inner side plates, each side plate set forming one brachiole facet at edge of ambulacrum (Text-Fig. 18H).

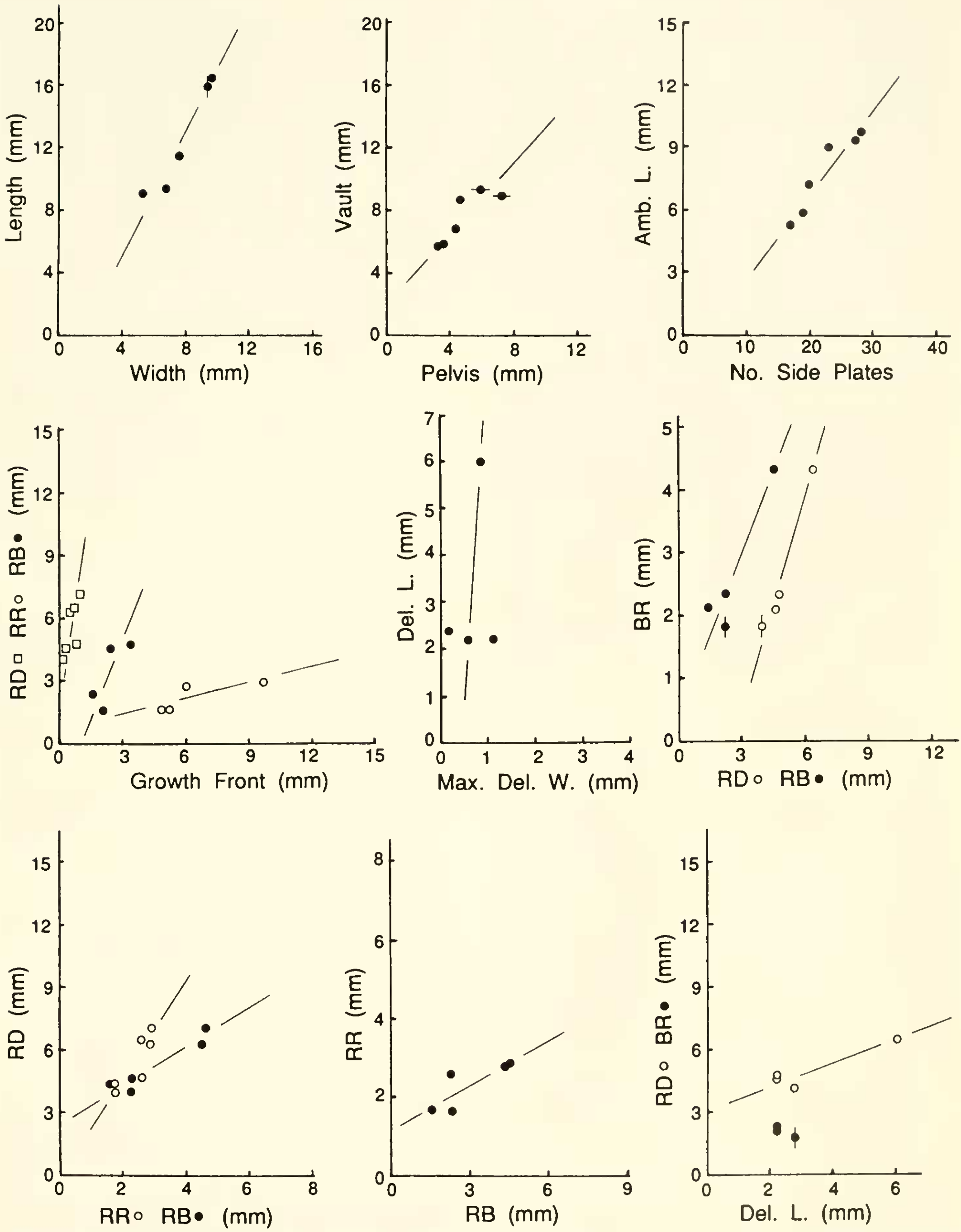
Main food groove extending down center of each ambulacrum, between side food grooves having about 3–5 lobes on each side formed by lancet; side food grooves long, empty into main food groove at 45° angle aborally to 80° angle adorally, each having 8–11 lobes on adoral side, 7–9 smaller lobes on aboral side, both formed by lancet and inner side plates, each side food groove leading to large brachiolar pit about 0.3 mm from edge of ambulacrum and two shallow depressions making up brachiole facet about 0.4 mm long and 0.25 mm wide, turned at 20–30° angle to side food groove, and slanted abmedially and adorally (Text-Fig. 18H; Plate 1, Fig. 3); edge of radial smooth, edge of deltoid body somewhat ridged, one pore per side plate along radials, alternating with brachiole facets; pores apparently absent along deltoid margin just above radiodeltoid suture, because deltoid edge grooved at each brachiole facet and ridges between grooves extend into apparent pore positions at edge of ambulacrum. Pore furrows well developed, arcuate, extending around lower edge of braciole facet, then laterally along raised center of inner side plate and often reaching lancet, pore furrows present along both radial and deltoid margins.

Hydrospire groups 10, poorly known, apparently three hydrospires per group below each ambulacral side.

Measurements for few complete specimens without appendages plotted in Text-Figure 20.

Ornament consists of fine to medium growth lines on basals and radials (Plate 1, Fig. 3), somewhat coarser growth lines on deltoids and along RHD growth front.

Brachioles preserved in at least four specimens, at least 21 mm long in largest example, tightly packed along edge of ambulacrum where attached (Plate 5, Figs. 10–11), apparently expanding in size away from theca for some distance before becoming smaller again; in theca about 15 mm long, brachioles from middle of am-



Text-Figure 20. Growth plots for six measured specimens (MCZ 871–876) of *Strongyloblastus laudoni*, n. sp. Because many specimens were incomplete, only 3–4 specimens could be plotted in some cases; short lines through some measurements indicate estimated values in broken specimens. Best-fit lines in all plots were hand fit.

bulacrum biserially-plated, about 18–19 mm long, 0.25 mm wide, and 0.3 mm deep, apparently a single set of distally slightly-imbricate brachiolar cover plates present, about 3.3 cover plates per brachiolar plate on each side, cover plates slightly arched over brachiolar food groove (Text-Fig. 18I). In holotype, tiny cover plates scattered over ambulacra and still organized into domed structure over adoral food grooves and central mouth (Plate 6, Figs. 28–29); many basal brachiolar plates still attached to edges of ambulacra in this specimen. Stem preserved in three paratypes; in theca about 15 mm long, 4.5 mm of proximal stem preserved, decreasing from 1.5 mm at theca to 0.8 mm at preserved distal tip, proximal columnals thin, expanding to basal attachment, about 5 per mm, distal columnals thicker, about 3 per mm (Text-Fig. 18G).

Studied Specimens. Holotype MCZ 871, paratypes MCZ 872–881 (10 specimens and plates), and MORI 001 (Welch Collection, Museum of the Rockies, Montana State University, Bozeman); 11 additional plates in MCZ 883.

Occurrence. Known from two localities in the Bridger Range, southwestern Montana, and one locality in the Little Belt Mountains, west-central Montana: all except one MCZ specimen from Northeast Baldy Mountain in the southern Bridger Range (21 specimens and plates, including the holotype) from two 6–8 in. (0.15–0.20 m) beds in the middle Paine Member about 150–175 ft (46–53 m) above the base of this member, single ambulacrum from the float about 115 ft (35 m) above the base at Baldy Mountain just to the south, and a single complete specimen from an unknown Lodgepole horizon at Ant Park in the Little Belt Mountains (Welch Collection).

Etymology. Named for Lowell R. Laudon, formerly at the University of Wisconsin, Madison, who first discovered complete blastoids in the Bridger Range and directed us to the rich Northeast Baldy Mountain locality in 1966.

Discussion. Strongyloblastus laudoni retains its juvenile obconical shape with a shorter vault and ambulacra and a lower pelvic angle into the adult stage instead of becoming elongate ellipsoidal as *S. breimeri* does. Other minor differences include the hypodeltoid apparently not being enlarged in *S. laudoni,* and the lancet occupying somewhat less of the ambulacral width; however, other features of the ambulacra, pore development, half-paired anispiracle, and anal deltoids are very similar. This species is also similar to *S. kirki* (see *Strongyloblastus* Discussion) but is less elongate with a lower L/W ratio and a higher pelvic angle, has a smaller stem facet, no pores along most of the deltoid because the deltoid edge is ridged, and may show other differences in the anispiracle and anal deltoids.

STRONGYLOBLASTUS SP.

Plate 6, Figs. 21–23; Text-Figures 18J–K and 19

A single small specimen from the lower Lodgepole Limestone apparently does not belong to either of the named species of *Strongyloblastus* known from this formation. This specimen (MCZ 870) is immature (5.5 mm long), but is well preserved and not like similar-sized specimens of *S. breimeri* or *S. laudoni* in its shape. It is briefly described here but not named.

Description. Specimen godoniform in shape (Text-Fig. 18J), relatively wide, interambulacra flat to slightly concave; theca 5.5 mm long, 5.2 mm wide, L/W ratio = 1.1; vault widely parabolic, slightly recurved, 3.5 mm long, pelvis low conical, slightly concave in profile, 2.0 mm long, V/P ratio = 1.8; pelvic angle 100–105°, much higher than either of the other Lodgepole species at this size. Basals three, relatively large, make up 50–60% of pelvis, slightly bulbous with small stem facet; radials five, large, fairly long, raised above ambulacra; regular deltoids four, very short, but just appearing on side of theca; ambulacra moderately long but without many side plate sets, slightly convex, ambulacral pores appear to die out just above radiodeltoid suture; spiracles well divided by deltoid septa, "C" spiracle separated from rest of half-paired anispiracle (Text-Fig. 18K); ornament consists of relatively coarse growth lines with several of these raised (Plate 6, Fig. 21).

Growth features included with *S. breimeri* for comparison (Text-Fig. 19).

Studied Specimen. MCZ 870.

Occurrence. Known from the lower Paine Member, Lodgepole Limestone, from beds 22–33 ft (7–10 m) above the base at Targhee Peak, just inside southeastern Idaho.

Discussion. This specimen occurs with *Tanaoblastus* in the same beds of the lower Lodgepole Limestone as *S. breimeri* normally does, but unless it is an abnormal growth variant, it does not appear to belong to this species. It also occurs in a different part of the field area from the narrow east-west strip where most specimens of *S. breimeri* have been found. This specimen is much wider with a lower L/W ratio and a larger pelvic angle than small specimens of *S. breimeri* (or *S. laudoni*); the raised growth lines are also different than most specimens of these species. Perhaps larger specimens of this form would also have been godoniform in thecal shape, but additional specimens will be necessary to determine this.

Family GRANATOCRINIDAE Fay, 1961
Subfamily CRYPTOBLASTINAE Fay, 1964
Genus TANAOBLASTUS Fay, 1961

Type Species. Pentremites roemeri Shumard, 1855.

Diagnosis. Spiraculate blastoids with a globular theca, ambulacra extending to base or nearly so, base moderately convex to flat, interradial sutures not depressed; eight widely separated spiracles and an anispiracle, two hydrospire folds beneath each side of ambulacrum; four anal deltoids, adoral superdeltoid, aboral hypodeltoid, and two hidden cryptodeltoids lying beneath hypodeltoid; regular deltoids of moderate size usually visible in side view, occupying from one-sixth to nearly one-half of thecal length, hypodeltoid usually slightly enlarged over regular deltoids, radials usually overlapping deltoids; ambulacra long and relatively narrow, lancet partly exposed toward adoral end, hydrospire plate present along radials bearing between 1.0 to 1.6 pores per side plate, pores usually absent along deltoids except for 1–3 pores located just above radiodeltoid suture in several species.

Occurrence. Early Mississippian (Late Kinderhookian = Late? Tournaisian), central and western U.S.A. (Missouri, Montana, Idaho, Utah, Wyoming?, Nevada?, Arizona?).

Discussion. Tanaoblastus differs from other closely related genera, such as *Cryptoblastus*, by having a slightly different thecal shape without depressed interradial sutures and by having a flat to moderately convex base. It differs from *Mesoblastus* by having only two hydrospire folds per side, a different number of pores along the radials, and larger but less ornamented deltoids. Two species of *Tanaoblastus* are especially abundant in western Montana and adjacent areas such as southeastern Idaho and northernmost Utah. Very similar species apparently occur in the early Mississippian of Missouri, especially in the Chouteau Limestone. None of the Montana material shows the hidden cryptodeltoids on the anal side, and it is still uncertain whether *Tanaoblastus* has four anal deltoids as Fay (1961) reported or whether it might be more advanced and have only two anal deltoids, an epideltoid, and a hypodeltoid. The Montana material studied here probably makes up the largest collections of *Tanaoblastus* that have ever been assembled.

TANAOBLASTUS HAYNESI (Clark), 1917

Plate 1, Figure 1; Plate 7, Figures 1–30; Text-Figures 21A–B, E–F, H, and 22

Schizoblastus haynesi, Clark, 1917, pp. 371–373, plate 1, figures 15–20.

Mesoblastus haynesi, Fritz and Cline, 1937, pp. 308–

309, plate 17, figures 10–12 (but not plate 17, figures 1–9).

Tanaoblastus haynesi, Fay, 1961, pp. 102 and 104, plate 37, figures 7–9.

Diagnosis. Theca globular, L/W ratio varies from about 0.9–1.2; ambulacra almost reaching base in small individuals, reaching base and protruding slightly in large ones; basals flat to moderately convex, fairly small, deltoids occupying one-third of theca length in small individuals, about one-sixth of thecal length in large ones, interambulacra flat to slightly concave; spiracles wide apart on summit, last pore at radiodeltoid suture; ornament consists of fine growth lines on radials, coarser bands along RD fronts, low ridges on basals.

Description. About 925 specimens of this species available for study from about 30 localities in western Montana (Table 1), ranging throughout the lower 75 ft (23 m) of the Lodgepole Limestone. The following description is based on the holotype specimen MCZ 347 described by Clark (1917) and about 40 other newly-collected specimens.

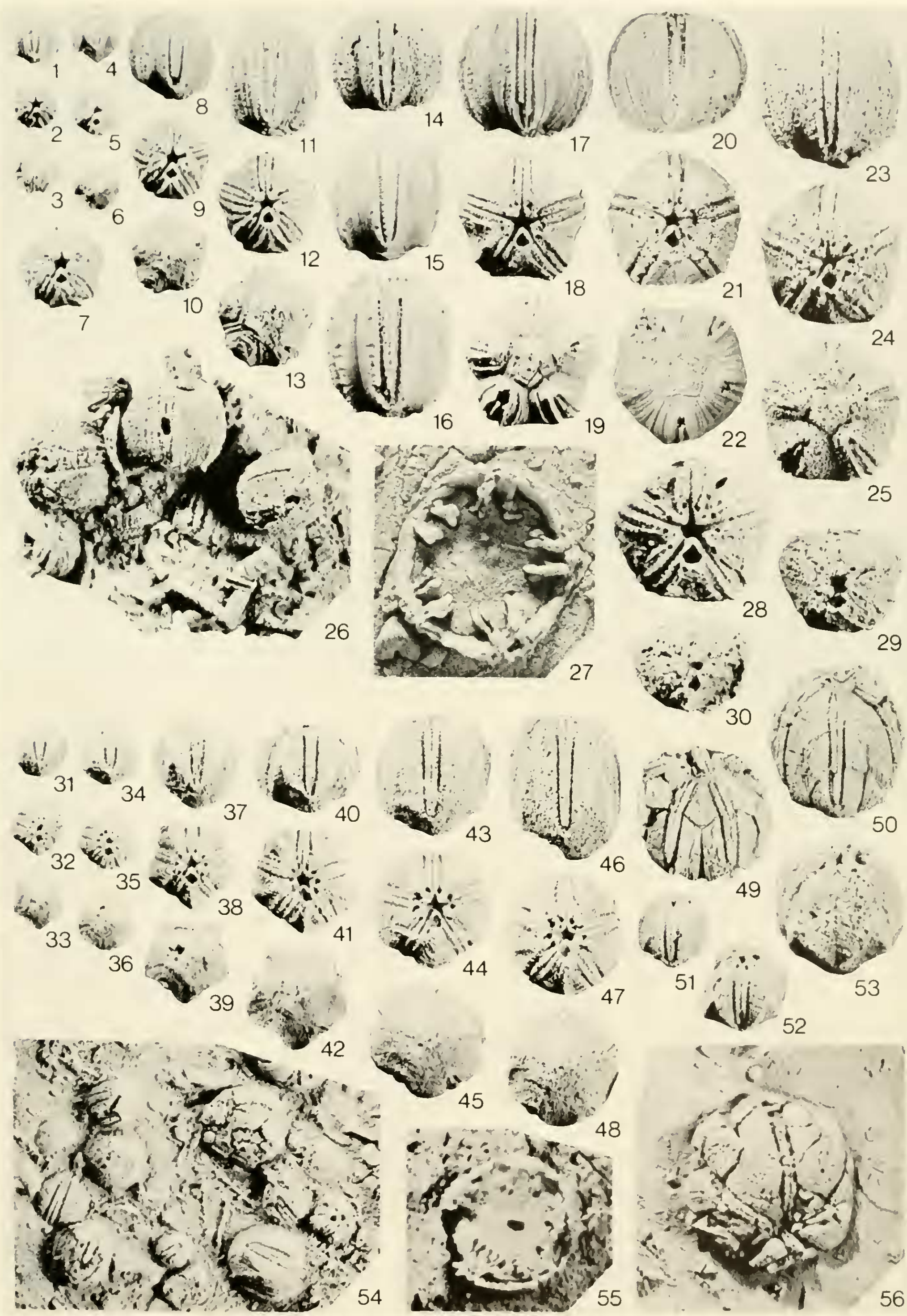
Theca globular, varying from elongate to squat, small thecae nearly spherical, larger ones more variable; vault rounded, pelvis slightly convex, basals moderately convex to flat, interambulacra usually slightly concave, but may be flat in some specimens, greatest width near midheight; smallest theca about 2.8 mm long, largest theca about 10 mm long and 9 mm wide (Plate 7, Figs. 1–25).

→

PLATE 7

Figures 1–30. *Tanaoblastus haynesi* (Clark), lower Paine Member, lower Lodgepole Limestone, 1–3 from Brazer Canyon, northeastern Utah, 4–6 and 8–13 from Targhee Peak, southeastern Idaho, 7 from White Peak, 14 and 17–19 from Squaw Creek, 15 from North Sawtooth Mountain, northwestern Montana, 16 from Northeast Baldy Mountain, 20–22 from Old Baldy Mountain, 23–25 and 29–30 from London Hills, 26 from Cowboy Canyon, 27 from Timber Butte, and 28 from Sixteen Mile Creek, all except 1–6, 8–13, and 15 from southwestern Montana. 1–3, D-side, top, and bottom views of very small theca USNM 16515 showing raised radial edges alongside ambulacra, ×2.7; 4–6, E-side, top, and bottom views of very small theca MCZ 1030; note relatively short ambulacra and nearly round cross section, ×2.7; 7, top view of medium-sized theca USNM 20163 showing eight spiracles and anispiracle, ×2.7; 8–10, B-side, top, and bottom views of medium-sized theca MCZ 1027; note globular shape and pentagonal cross section, ×2.7; 11–13, C-side, top, and bottom views of medium-sized elongate theca MCZ 1031 showing ornament, enlarged and slightly raised hypodeltoid, and partly-exposed lancet, ×2.7; 14, B-side view of medium-sized squat theca USNM 20602 having rather coarse silicification, ×2.7; 15, C-side view of large elongate theca MCZ 1026; note fine ornament and flat interambulacra, ×2.7; 16, C-side view of medium-sized elongate theca MCZ 1067 showing plate ornament, ambulacral pores ending at radiodeltoid suture, and slight lancet exposure, ×4; 17–19, A-side, top, and bottom views of large squat theca USNM 20603; note fine ornament, raised basals, and slightly concave interambulacra, ×2.7; 20–22, E-side, top, and bottom views of large squat holotype MCZ 347 showing ornament, short but visible deltoids, and relatively large flat basals (A ray at bottom), ×3.0; 23–25, D-side, top, and bottom views of very large elongate theca MCZ 1028; note coarse silicification, small raised basals, and missing side plates, ×2.7; 26, cluster of seven small to medium-sized thecae on partly-etched slab MCZ 1038, ×3.2; 27, cross section MCZ 1025 showing two well-preserved silicified hydrospires beneath each ambulacral edge, ×5; 28, enlarged top view of theca MCZ 1035; note eight spiracles and anispiracle plus well-preserved ambulacra, ×4; 29–30, top views of abnormal thecae MCZ 1036 and 1037, both of which lack the A ambulacrum, ×3.2.

Figures 31–56. *Tanaoblastus allanensis* Sprinkle and Gutschick, n. sp., lower Allan Mountain Limestone, four localities around Crown Mountain, northwestern Montana. 31–33, E-side, top, and bottom views of small angular paratype MCZ 964 showing ambulacra not reaching base of theca, ×2.8; 34–36, C-side, top, and bottom views of small rounded paratype MCZ 965; note well-preserved spiracles and anispiracle, ×2.8; 37–39, C-side, top, and bottom views of medium-sized very angular paratype MCZ 968 showing pentagonal cross section and depressed ambulacra, ×2.8; 40–42, A-side, top, and bottom views of medium-sized angular paratype MCZ 970; note long deltoids and abnormal basals (three azygous, one zygous), ×2.8; 43–45, B-side, top, and bottom views of large rounded holotype MCZ 963 showing ornament on large deltoids and convex base with secondary deposits around small stem facet, ×2.8; 46–48, C-side, top, and bottom views of large rounded paratype MCZ 972; note large deltoids with low central ridge and rounded cross section, ×2.8; 49, AB? interray view of large crushed paratype MCZ 975 showing plate sutures and ornament, ×2.7; 50, B-side view of large crushed paratype MCZ 977; note well-preserved ornament and few ambulacral pores above radiodeltoid suture, ×2.7; 51, oblique E-side view of rounded paratype MCZ 967 showing few pores alongside lower deltoids, ×2.7; 52, oblique E-side view of angular paratype MCZ 976; note ambulacrum, spiracles, and few ambulacral pores above radiodeltoid suture, ×2.7; 53, oblique E-side view of abnormal paratype MCZ 969; E ambulacrum and its lancet missing and surrounding thecal plates in contact across sinus, ×4; 54, cluster of nine or more small to medium-sized thecae on paratype slab MCZ 978, ×2.5; 55, paratype cross section MCZ 974 showing holes for hydrospires in chert-filled interior, ×4.3; 56, oblique top view of very large crushed paratype MCZ 973 in slab; note large deltoids and broken thecal plates, ×2.5.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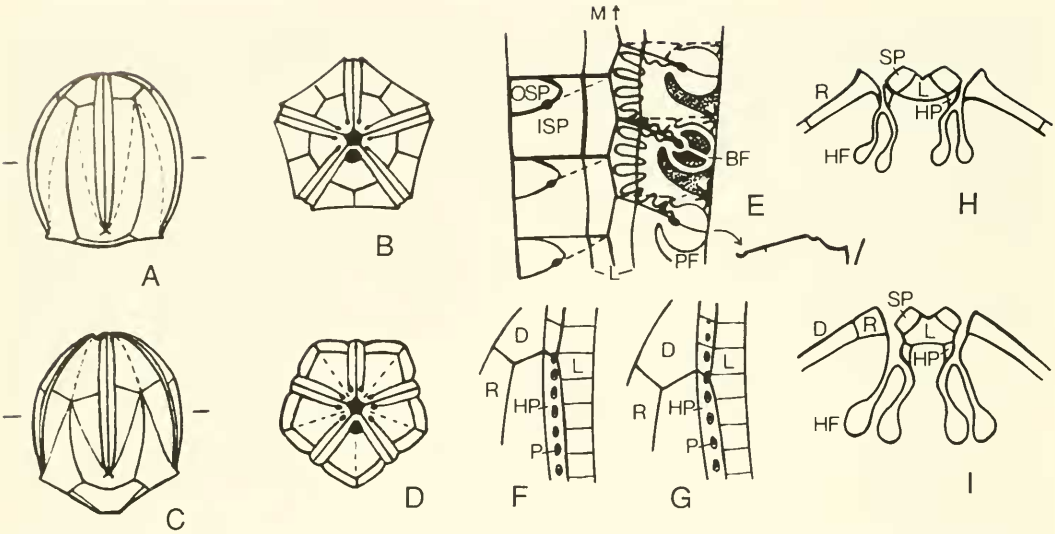


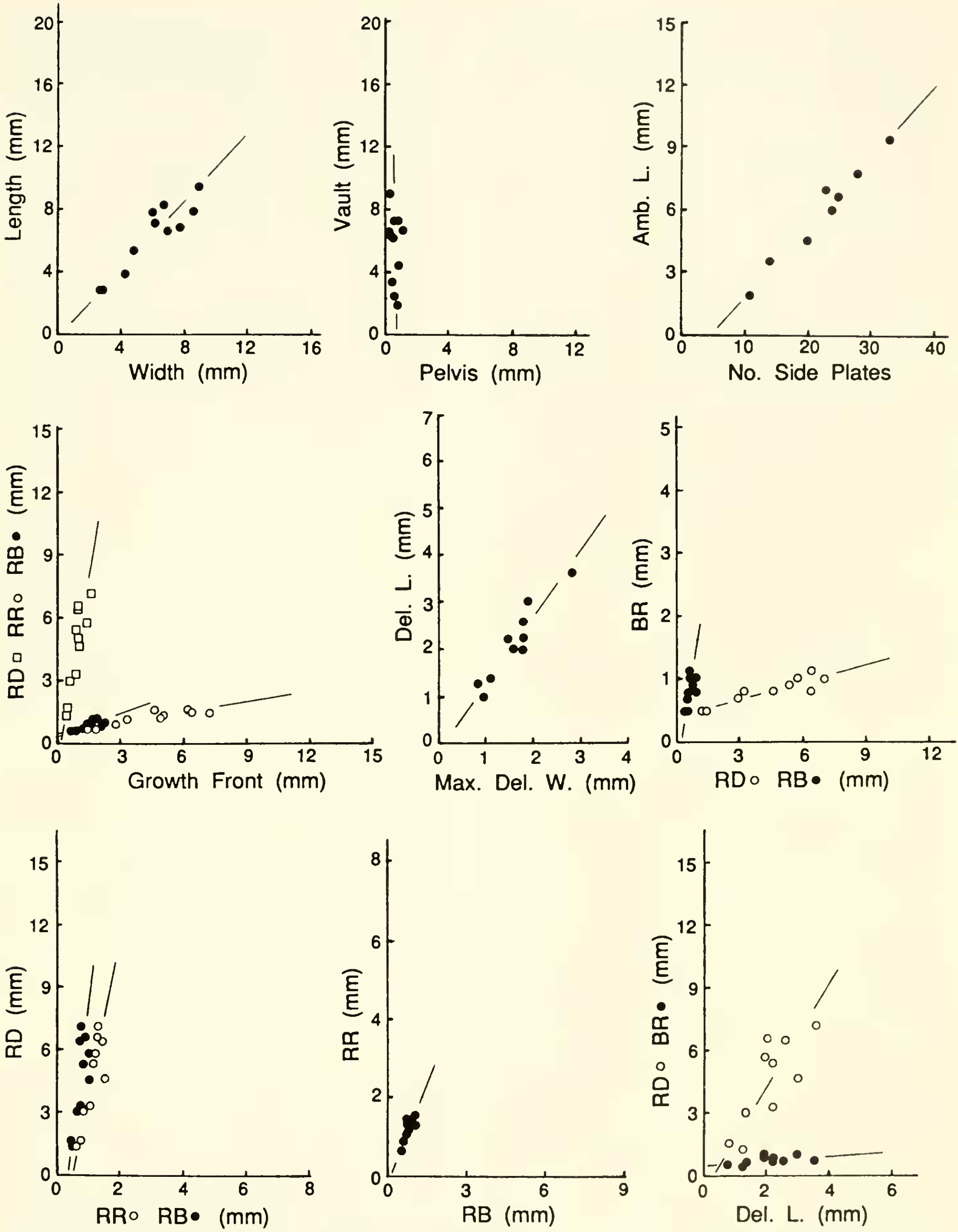
Text-Figure 21. Morphologic features of *Tanaoblastus haynesi* (Clark) (A–B, E–F, H) and *T. allanensis*, n. sp. (C–D, G, I). A–D, side and summit views of large elongate thecae showing maximum width (short lines) near midheight, longer deltoids and shorter ambulacra in *T. allanensis* (C–D), and difference in interambulacral shape (flat to slightly concave in *T. haynesi* vs. convex to humped in *T. allanensis*). E, enlarged ambulacrum in figured *T. haynesi* specimen MCZ 1024; note central lancet (L) and inner and outer side plates (ISP and OSP) supporting large brachiole facets (BF) at edge of ambulacrum with pore furrow (PF) wrapping around lower edge; cross section is along side food groove and facet, and small arrow points toward mouth (M). F–G, comparison between *T. haynesi* (F) and *T. allanensis* (G) showing that pores (P) through hydrospire plate (HP) either stop at suture between radials (R) and deltoid (D) when side plates missing from lancet (L), or extend short distance further along deltoid edge; F drawn from specimen MCZ 1024, G from paratypes MCZ 965 and 967. H–I, cross sections of ambulacra in *T. haynesi* specimen MCZ 1025 (H) and *T. allanensis* paratype MCZ 974 (I); note lancet (L) overlapped by side plates (SP) in ambulacra and shape of two hydrospire folds (HF) and hydrospire plate (HP) beneath each side of ambulacrum and adjacent radial (R) or deltoid (D).

Basals three, normally arranged, two larger and one smaller (azygous), usually slightly convex in profile except in small thecae where moderately convex, relatively small, occupying 50 to 60% of pelvis (Plate 7, Figs. 19, 22, and 25). In medium-sized theca, azygous basal 1.6 mm long, 1.6 mm wide, larger basals about same length, and 2.4 mm wide. Center of basal set covered with thin secondary deposits obscuring growth lines and bearing central stem facet about 0.7–0.9 mm in diameter, with about 25–26 crenulae extending one-fourth of distance in from margin, and small round central lumen about 0.07–0.08 mm in size surrounded by a slightly depressed region (Plate 7, Fig. 19).

Radials five, large, making up most of thecal surface (greater than 60%), recurved at base with short body occupying 40–50% of pelvis, and long moderately curved limbs enclosing long ambulacral sinus. Radiodeltoid suture nearly straight, RD axis dominates growth (Text-Fig. 22), small radial lip near origin of radials pointing outward or slightly downward.

Regular deltoids four, relatively small, make up 16–20% of length in large thecae, DR suture makes angle of about 135°; deltoid lips small, form edges of mouth, two elliptical spiracles notched in aboral corners of lip with small ridge around inside edge of spiracles; deltoid body larger, diamond-shaped, moderately concave adorally, slightly concave to flat aborally, radials slightly overlap deltoids at radiodeltoid suture.

Anal deltoids apparently four, adoral superdeltoid (=lip of regular deltoids), two deep, hidden cryptodeltoids (forming septa separating anus from posterior hydrospires beneath hypodeltoid), and large aboral hypodeltoid (=regular deltoid bodies), hypodeltoid slightly enlarged over other del-



Text-Figure 22. Growth plots for 11 measured specimens (MCZ 1026–1028, 1030–1031, 1066–1067, holotype MCZ 347, USGS 16815 and 20602–20603) of *Tanaoblastus haynesi* (Clark). Note that the pelvis shows no apparent growth in its contribution to thecal length (top center) and very slow growth in RB and RR. Best-fit lines in all plots were hand fit.

toid bodies. Anispiracle nearly circular, formed by superdeltoid adorally, hypodeltoid aborally, and small segment of side plates from adjacent adoral ambulacra laterally (Plate 7, Figs. 18 and 21).

Mouth central on summit, formed by regular deltoid lips plus superdeltoid, pentagonal to slightly star-shaped, slightly larger than anispiracle, has lobes and sockets on margins.

Ambulacra five, long and fairly narrow, usually extending to or near base, moderately curved along length, moderately to strongly convex (actually biconvex) in cross section (Text-Fig. 21E), highest points at or slightly above level of adjacent thecal plates, edges slightly depressed below thecal plates, widest at radiodeltoid suture, lancet slightly exposed along most of length, about one-third to one-half of its width exposed, occupying about one-fourth to one-third of ambulacral width, side plate sets on bevelled lancet edge, inner side plates modified rectangular, outer side plates small and triangular, occupy abmedial aboral margin of inner side plates, each set of inner and outer side plates bears a fairly large, nearly circular, brachiole facet at edge of ambulacrum, small round brachiolar pit near highest point of ambulacrum at end of side food groove, two depressed facets just abmedial to this, where brachiolar plates attached (Text-Fig. 21E). Large pore furrow curving around aboral side of brachiole facet; 3–4 lobes along main food groove usually in lancet material, 3–4 lobes adorally and usually two lobes aborally along short side food grooves mostly on inner side plates. Hydrospire plate present along radials beneath edge of ambulacra, formed by radial material, side plate impressions on lancet and adjacent deltoid edge but not on adjacent radial edge or hydrospire plate (Text-Fig. 21F), one row of pores in hydrospire plate, between 1.5–1.6 pores per side plate set, pores slightly elongate along ambulacral length, last pore at radiodeltoid suture round to very elongate, apparently place where new pores inserted.

Hydrospires in 10 groups, two folds per ambulacral side, folds hang down into thecal cavity (Text-Fig. 21H; Plate 7, Fig. 27), folds have thin parallel walls and an enlarged tube at bottom.

Ornament consists of fine growth lines along RR front with slightly pustular periodic markings, basals have closely spaced pustular periodic markings, relatively coarse growth lines on RD fronts expanding towards deltoids, DR growth front variable ranging from fine growth lines to fairly coarse pustule-bearing bands (Plate 1, Fig. 1). Radials and deltoids have raised nodes along ambulacra, moderate secondary deposits forming stem facet, slight secondary deposits forming radial lips, edges of ambulacra, and slightly raised adoral edge of hypodeltoid.

Measurements of growth series specimens plotted in Text-Figure 22. Small specimens have a fairly large convex base with short ambulacra, a relatively small V/P ratio, and fairly large deltoids. Large specimens tend to become more elongate or more squat with relatively small base, ambulacra usually reaching base, higher V/P ratio, and deltoids occupying less of thecal length.

No stems or brachioles known for this species. Three abnormal specimens in about 925 examined (0.3%), all of these four-sided with an ambulacrum that remained very small or never developed. Radials and deltoids appear normal, but radial sinus closed and deltoids in lateral contact; two abnormalities affect "A" ambulacrum, one affects "D" ambulacrum, very small spiracles possibly present in abnormal ray (see Plate 7, Figs. 29–30).

Studied Specimens. Holotype MCZ 347, paratypes MCZ 341; other studied or measured specimens MCZ 1024–1038, USGS Collections 16815, 20163, and 20602–3; other specimens MCZ 1039.

Occurrence. Known from between 5 and 75 ft (1.5–23 m) above the base of the Paine Member of the Lodgepole Limestone at 30 or more localities in southwestern and west-central Montana, southeastern Idaho, and northeastern Utah; also found in the lower Allan Mountain Limestone at North Sawtooth Mountain in northwestern Montana (see Table 1).

Discussion. Tanaoblastus haynesi characterizes the lower Paine Member of the Lodgepole Limestone in much of western Montana, southeastern Idaho, and northeastern Utah. This blastoid seems to be present at most sections of the Montana Facies of Sando (1976). The preservation of these silicified specimens ranges from only fair (see Plate 7, Figs. 23–25), at localities such as London Hills, to excellent when extracted with acetic acid at localities such as Standard Creek (see Plate 1, Fig. 1) and Targhee Peak (Plate 7, Figs. 8–13). This species is similar to several species from the Mississippi Valley, such as *T. missouriensis* and *T. tenuis*; it differs from these species by usually being less elongate, by having flat to slightly concave interambulacra, by having somewhat stronger growth bands on the basals and periodically on the radials, by having a somewhat different number of pores per side plate set along the radials, and by having different length (usually shorter) deltoids. *Tanaoblastus haynesi* differs from *T. allanensis*, n. sp., by having a shorter base, flat to slightly concave interambulacra, the last pore at the radiodeltoid suture, and shorter deltoids.

TANAOBLASTUS ALLANENSIS
Sprinkle and Gutschick, new species
Plate 7, Figures 31–56;
Text-Figures 21C–D, G, I, and 23

Diagnosis. Theca globular, length nearly equal to width, V/P ratio averaging 3.1, interambulacra moderately convex to strongly angular; deltoids long, occupying between one-third and one-half of thecal length, radials abut deltoids; ambulacra relatively long, not reaching base of theca, 1–3 pores just above radiodeltoid suture; ornamented with moderately coarse growth lines.

Description. At least 174 specimens available for study, all from four localities in the lower Allan Mountain Limestone at Crown Mountain in northwestern Montana. Holotype MCZ 963, and 16 other paratypes used for the following description.

Theca globular to elongate, sometimes squat, rounded to flaring pentagonal in cross section, vault rounded, pelvis slightly to moderately convex, maximum width at or considerably above midheight, ambulacra flush with adjacent thecal plates; smallest theca 2.9 mm long, largest free theca about 8.3 mm long and 6.8 mm wide, very large obliquely crushed theca in slab at least 8.5 mm long and 11.5 mm wide; L/W ratio ranging from 0.85 to 1.21, averaging 1.0, V/P ratio ranging from 1.95 to 4.38, and averaging 3.1, pelvic angle ranging from 90° to 120° and averaging 112°, based on 10 specimens in growth series.

Basals three, normally arranged, two larger and one smaller (azygous), fairly small, make up 50–60% of pelvis, usually convex in side view with small stem facet (Plate 7, Fig. 42), in large specimen azygous basal 2.1 mm long and wide, larger basals about same length and about 2.8 mm wide.

Radials five, fairly large, make up much of thecal surface (about 50%), have small lip at radial origin, body fairly short, making up about 40% of pelvis, limbs fairly long, making up half or more of ambulacral sinuses, adoral end of radials raised, producing convex to angular cross section.

Regular deltoids four, fairly large, occupying one-third or more of curved ambulacral sinuses, between one-third and one-half of thecal length (Text-Fig. 21C), rhombic-shaped, aboral end strongly convex or crested to meet raised adoral radials, radiodeltoid suture forms angle between 90° and 130°, radials appear to abut deltoids without any overlap. Spiracles eight, slightly elliptical, at lateral margins of deltoid lips, about 0.6 mm apart across deltoids and across ambulacra, slight ridges just inside spiracles on edges of deltoids; mouth central on summit, about 0.6–0.7

mm in diameter, slightly wider than long, star-shaped to pentagonal, margins formed by regular deltoid and superdeltoid lips.

Anal deltoids apparently four, small superdeltoid adorally (=lips of other deltoids), two cryptodeltoids apparently hidden below hypodeltoid, and aboral, fairly large hypodeltoid (=body of other deltoids); hypodeltoid either same size or slightly enlarged over other deltoids, raised and slightly hooded adorally over anispiracle, which is surrounded by superdeltoid adorally, few side plates of ambulacra laterally, and hooded hypodeltoid aborally, anispiracle rounded to pentagonal, slightly smaller than mouth, about 0.6 mm in diameter. Cryptodeltoids difficult to see, may form septa separating posterior hydrospires from anus deep within anispiracle.

Ambulacra five, relatively long but not reaching base of theca, rather narrow, flush with or slightly depressed below adjacent thecal plates, slightly to moderately convex; lancet slightly exposed along most of length, occupying one-fourth to one-third of ambulacral width, mostly forming main food groove and adjacent lobes in center of ambulacrum, side food grooves enter main food groove at 40–70° angle. Side plates normally developed, inner side plates rectangular, small triangular outer side plates notch aboral abmedial edge of inner ones, together supporting relatively small brachiole facet at edge of ambulacrum. Between side food grooves, 4–5 lobes along main food groove, usually 3 adoral lobes and 2 small aboral lobes along each side food groove, which leads to small brachiolar pit and two small hemispherical depressions where brachiole attached. Pores developed in hydrospire plate alongside ambulacra, side plates do not completely cover hydrospire plate and pores, average of about 1.2 pores per side plate set along radials, pores absent along much of deltoid except at aboral end where 1–3 extra pores located just above radiodeltoid suture (Text-Fig. 21G).

Hydrospires in 10 groups, two hydrospires per ambulacral side, folds hang down into thecal cavity with thin lamellae and enlarged tubes at bottom, entrance to hydrospires through pores in hydrospire plate (Text-Fig. 21H; Plate 7, Fig. 55).

Ornament consists of moderate to fairly coarse growth lines on basals, radials, deltoids, and hypodeltoid, ornament along RD and DR fronts especially coarse (Plate 7, Figs. 44 and 50). Secondary deposits minor, forming stem facet and small radial lips.

Measurements of 10 specimens in growth series plotted in Text-Figure 23. Relatively little change in thecal shape with increasing size.

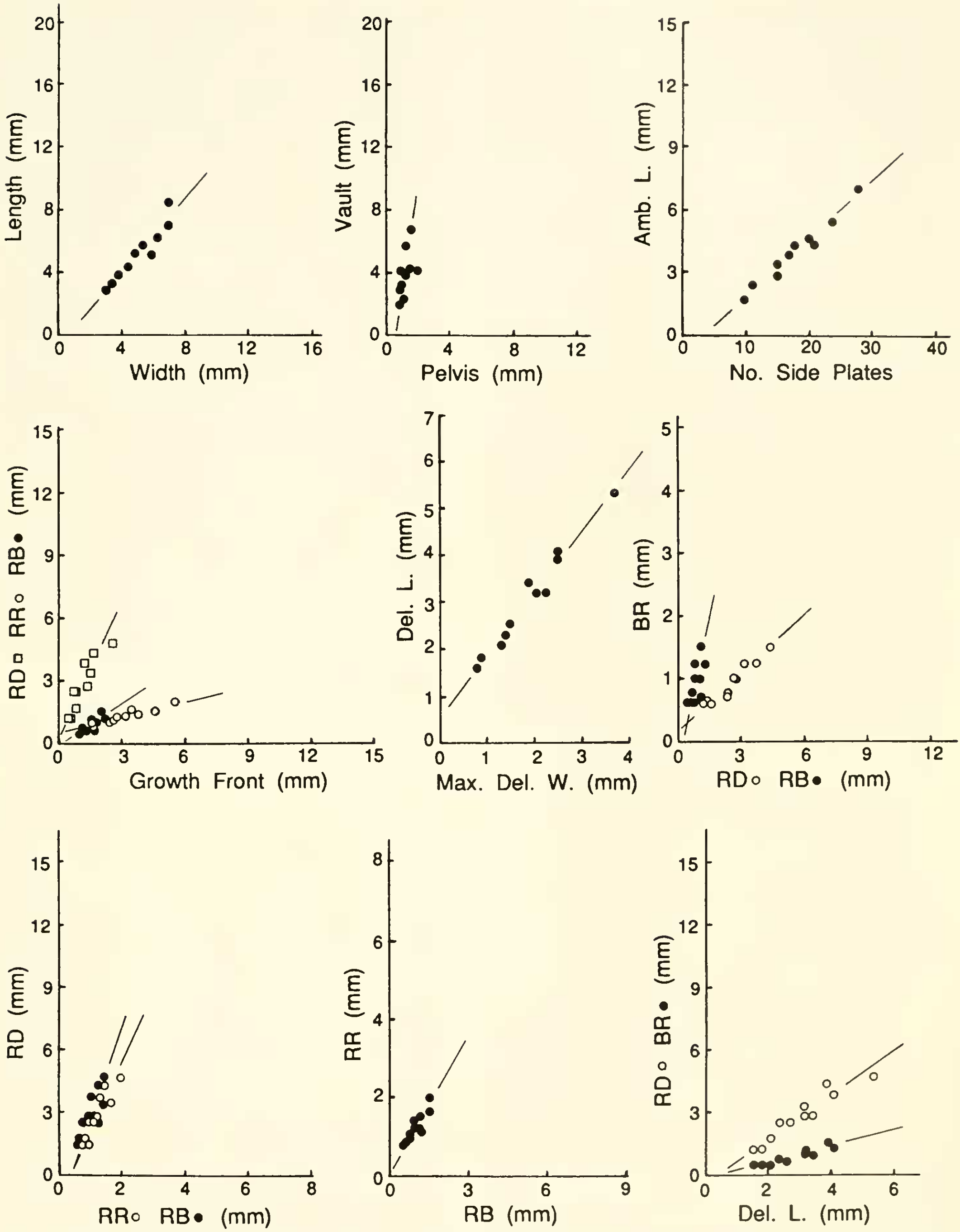
No stems or brachioles known for this species. Two abnormal thecae found in 174 examined (1.1%); one has no "E" ambulacrum although "E" radial appears normal-sized with limbs in contact and DE and EA deltoids abut each other apparently with two tiny spiracles near normal positions (Plate 7, Fig. 53). Other theca has four basals, one larger and three smaller; one of larger basals (apparently DA) split into two smaller plates, resembling azygous AB basal.

Studied Specimens. Holotype MCZ 963, paratypes MCZ 964–979, other additional specimens MCZ 980.

Occurrence. All studied specimens come from the area around Crown Mountain, between 11 and 35 ft (3.5–11 m) above the base of the Allan Mountain Limestone in northwestern Montana.

Etymology. Named for the Allan Mountain Limestone, where this species occurs.

Discussion. Tanaoblastus allanensis appears to be a paedomorphic derivative of some other *Tanaoblastus* species, perhaps *T. haynesi* which also occurs in the Early Mississippian of western Montana. It shows considerable resemblance to the juvenile specimens of this species and some similarity to species known from the Chouteau Limestone in Missouri. The convex base, long deltoids, relatively long ambulacra that do not reach the base, and convex to angular shape in cross section are all features similar to juveniles of *T. haynesi*,



Text-Figure 23. Growth plots for 10 measured specimens (MCZ 863–872) of *Tanaoblastus allanensis*, n. sp. Note slow growth in pelvis because of slow growth in RB and BR. Best-fit lines in all plots were hand fit.

although the cross section is not so angular in that form. The small size of most adult specimens of *T. allanensis* may also agree with this possible derivation. *Tanaoblastus allanensis* shows some resemblance to Mississippi Valley forms such as *T. tenuis* (Hambach) and *T. roemeri* (Shumard) in its globular cross section and protruding base, but the deltoids are not so angular in either of these Missouri forms and the base is much less pronounced than in *T. allanensis*. These Chouteau species do not differ much among themselves, and we question whether all of these are really distinct species.

The cross-sectional profile of *T. allanensis* is probably the most variable feature of this species. Rounded forms and highly angular forms are fairly easy end members to pick out of the available material, but many intermediates exist and some forms cannot be assigned to one or the other with any certainty. We considered the possibility that two separate species might be present in this Crown Mountain material, but decided that these are probably highly variable individuals in a single species because of the many intermediates and the occurrence of both forms at all four of the Crown Mountain sections. The angularity in cross section probably represents a growth feature that was not highly controlled genetically.

Genus CRYPTOBLASTUS Etheridge and Carpenter, 1886

Type species. Pentremites melo Owen and Shumard, 1850.

Diagnosis. Spiraculate blastoids with an ellipsoidal or ovoid theca, base fairly small, usually with small, depressed basals; eight spiracles plus an anispiracle; four anal deltoids present, small adoral superdeltoid, two deep, hidden cryptodeltoids, and aboral hypodeltoid that is not enlarged; ambulacra long, slightly depressed, extend to base of theca, lancet slightly exposed along most of length, hydrospire plate present with about 1.5 pores per side plate set along radials, pores absent along deltoids; interradial sutures often depressed, radials overlap deltoids.

Occurrence. Early to Middle Mississippian (Kinderhookian to Osagean), Mississippi Valley and northwestern Rockies, plus southern Canadian Rockies.

Discussion. At least five species of globular blastoids occur in the U.S. and Canadian Rockies that may belong to *Cryptoblastus*; three of these occur in the Lodgepole Limestone in western Montana. Two other species, including the form called *Mesoblastus haynesi* described by Fritz and Cline (1937) and a form that occurs in the Banff Formation near Lake Minnewanka in southern Alberta, also appear to belong to *Cryptoblastus*. The three Lodgepole species occur in the middle and upper parts of this unit at different localities; unfortunately, none of them is particularly common, complete, or well preserved. For this reason they are not formally named in this paper, but are only briefly described and illustrated.

CRYPTOBLASTUS? species A
Plate 4, Figures 14–28;
Text-Figures 24A–D and 25

About 11–12 silicified specimens and several fragments and plates from two localities near the top of the Lodgepole Limestone appear to belong to one species of *Cryptoblastus*. This species has an ellipsoidal theca with a rounded vault and a medium-sized base having a concave basal cavity, a L/W ratio ranging from 1.04 to 1.32, averaging 1.15 in the five nearly complete specimens, relatively short deltoids, and nearly paired, closely set spiracles.

Theca ellipsoidal, base medium-sized, depressed in center, profile in oral view pentagonal with flat to slightly convex interambulacra. Large, nearly complete theca 8.0 mm long, 7.6 mm wide, vault occupying entire length, pelvis depressed, basals inset about 1.0 mm above tips of ambulacra. Basals three, small, make up shallow basal cavity, deepest part occupied by fairly small stem facet about 1.0 mm in diameter; radials five, very large, occupy about 80% of thecal surface, strongly recurved at base with short body about 1.5 mm long and long limbs about 7.0 mm long; deltoids four, short, barely appearing on side of theca, body about 1.2 mm long, with short lip adorally; hypodeltoid also small, not enlarged, apparent superdeltoid slightly wider than other deltoid lips, cryptodeltoids not seen but thin septa internally separate anus from posterior spiracles; eight closely spaced spiracles on summit, thin septum connects deltoid body and lip, and barely separates spiracles at surface, spiracles widely separated across adjacent ambulacra. Ambulacra five, long, extending to base of theca, where small radial lips present, ambulacra convex and angular, nearly flush with adjacent thecal plates, lancet appears slightly exposed along most of length, side plates numerous, hydrospire plate with 1.5–1.6 pores per side plate set along radials, pores apparently absent along short deltoids, thin raised ridges on edges of radials and deltoids. Ornament consists of fine growth lines with small pustules on radials, coarser growth lines on RD fronts and deltoids, radial body and basals nearly smooth.

Studied Specimens. MCZ 1045–1061 plus one theca and several plates in USGS Collection 20670 (Sando Collection).

Occurrence. Upper Lodgepole Limestone, most specimens from about 655 ft (200 m) above the base in the upper half of Woodhurst Member at Sacagawea Peak, northern Bridger Range, southwestern Montana; single specimen (MCZ 1059) with similar features in a float slab from an unknown footage in the upper Lodgepole? Limestone at Pole Canyon, northern Tobacco Root Mountains, southwestern Montana.

Discussion. This form has many features similar to *Cryptoblastus melo*, but some that are different. The medium-sized, slightly concave base is somewhat different, and this form lacks the depressed sutures that characterize *C. melo*. The number of anal deltoids is unknown; if it is four as suspected, this form would be most closely related to *Cryptoblastus* and has been questionably assigned to that genus here. More and better-preserved specimens will be necessary to confirm this assignment.

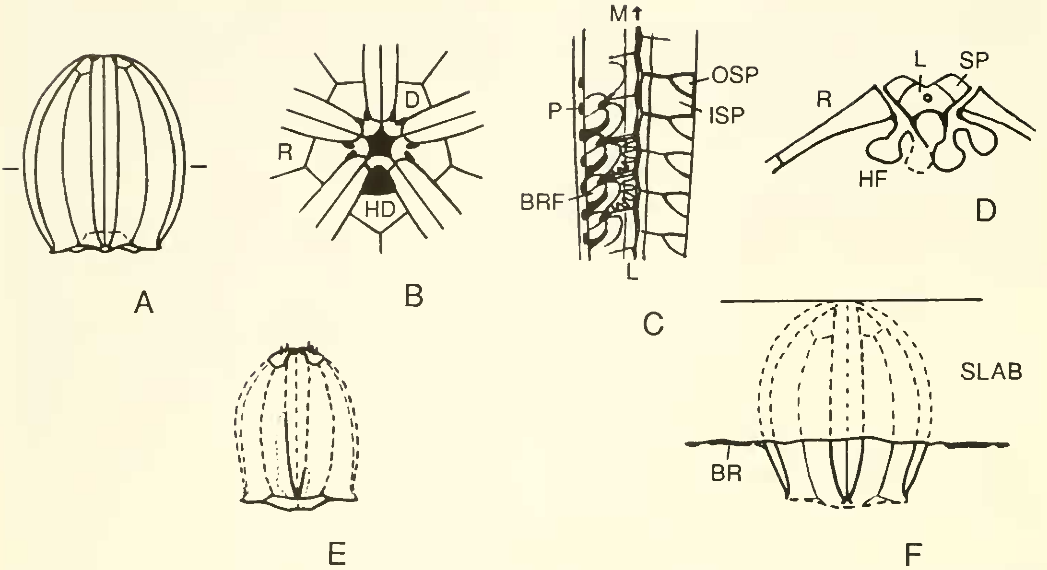
CRYPTOBLASTUS? species B

Plate 4, Figures 31–34; Text-Figure 24E

A small number of distinctive plates belonging to a globular blastoid were recovered from acid residues from the large *Koryschisma* block found at Bandbox Mountain in west-central Montana. This form is known from only four plates or fragments, but may also belong to *Cryptoblastus*. Available material includes a partial base with all three basals and parts of two radials, a partial radial with one nearly complete limb and ambulacral margin, and two small spine-bearing deltoids.

Base nearly flat, fairly wide, basals three, slightly convex, occupy 55–60% of short pelvis, stem facet protrudes slightly, about 1.2 mm in diameter, azygous basal about 1.9 mm long, 2.1 mm wide, larger basals about same length, about 2.5 mm wide, both basals and radial bodies ornamented with fine growth lines. Radial bodies short, limbs long, radials at least 6.5 mm long in largest fragment, ambulacra absent, but some evidence for pores along radial margin (in hydrospire plate?), radials have medium-sized lips pointing outward at tips of ambulacra, possibly two hydrospire folds per ambulacral side, ambulacra apparently narrow. Deltoids short, body ornamented with fairly coarse growth lines, adoral tip of deltoid body bears either two or three large spines (Plate 4, Fig. 31–32), thin septum leading from body to lip implies spiracles closely spaced or possibly paired, possibly two hydrospire folds beneath deltoid body leading to spiracles, radials appear to overlap deltoids, and radiodeltoid suture forms angle near 125°.

Studied Specimens and Occurrence. MCZ 1041–1044 from a block of limestone



Text-Figure 24. Morphology of *Cryptoblastus*? sp. A (A–D), *Cryptoblastus*? sp. B (E), and *Cryptoblastus*? sp. C (F). A, side view of large theca based on MCZ 1047 showing ellipsoidal shape (short lines at maximum width) with wide concave base, long fairly narrow ambulacra, and short deltoids just visible in side view, ×3.3. B, enlarged summit view in MCZ 1046; note closely set spiracles, small deltoids (D), and hypodeltoid (HD), ×5. C, plan view of ambulacrum based on MCZ 1050 and 1056 showing lancet (L) slightly exposed in center, large inner and small wedge-shaped outer side plates (ISP and OSP), and small brachiole facet (BRF) at edge of ambulacrum alongside hydrospire plate with pores (P), ×6.6. D, cross section of ambulacrum in MCZ 1054; note lancet (L) mostly covered by side plates (SP) and two hydrospire folds (HF) beneath each side of the ambulacrum, ×5. E, reconstructed thecal shape based on fragments MCZ 1041–1044 showing slightly convex base and spiny deltoids, ×2.5. F, reconstructed thecal shape in MCZ 1040 which is mostly buried in a slab and draped with brachioles (BR), ×3.3.

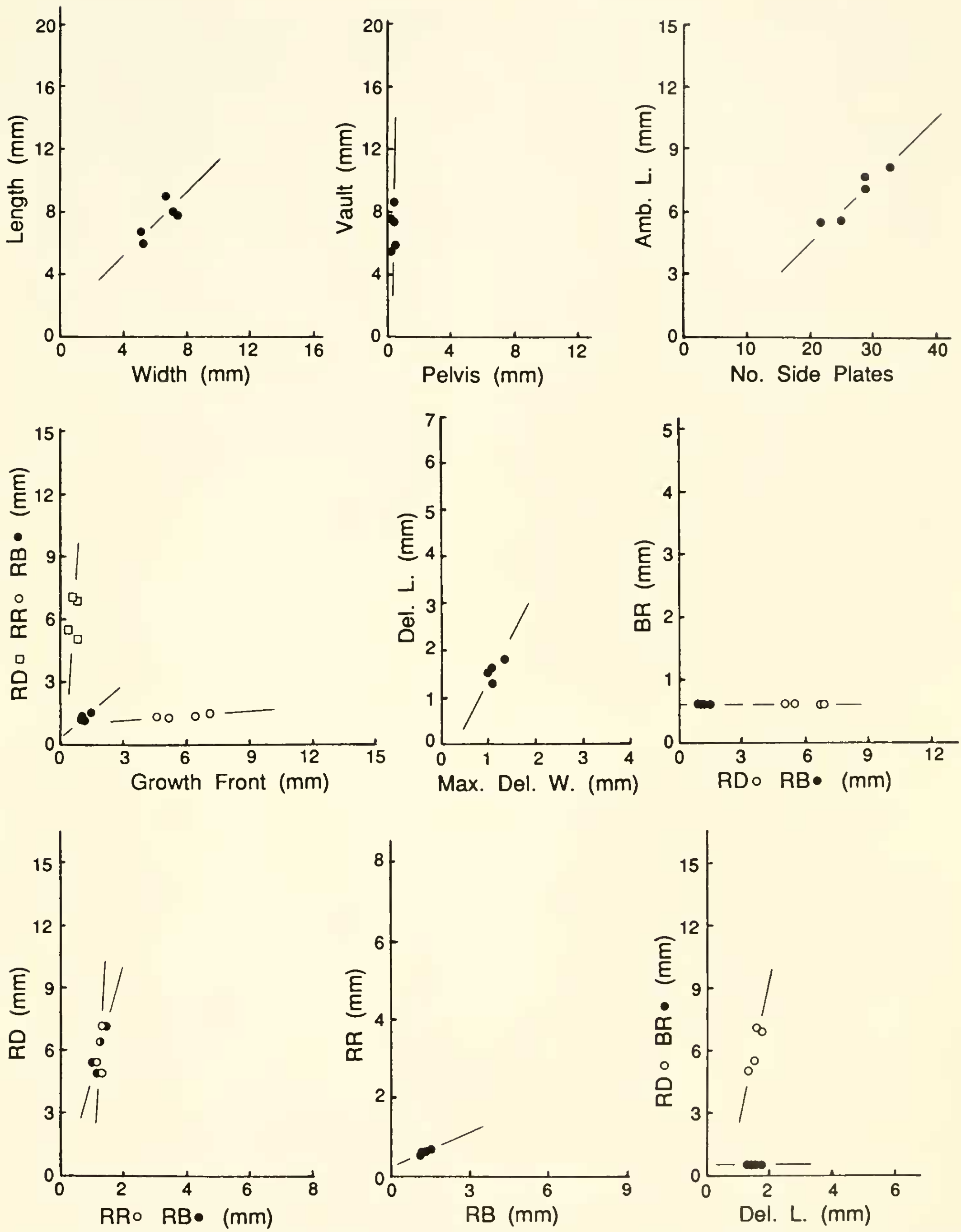
about 170–175 ft (52–53 m) above the base of the Paine Member, Lodgepole Limestone, at Bandbox Mountain, Little Belt Mountains, west-central Montana. This species is apparently a rare spiraculate occurring with the fissiculate *Koryschisma elegans*.

Discussion This species has a flat to slightly convex base and spiny deltoids unlike the other species of *Cryptoblastus*? and unlike the type species *C. melo*. The species is probably new but is not named here because of the fragmentary specimens.

CRYPTOBLASTUS? species C
Plate 4, Figures 29–30; Text-Figure 24F

This form is known from a single specimen from the middle Lodgepole Limestone at Northeast Baldy Mountain, southern Bridger Range, southwestern Montana. It occurs with numerous specimens of *Montanablastus baldyensis* and less common specimens of *Strongyloblastus laudoni*. The specimen is sitting vertically in a slab of limestone with the base exposed, weathered, and partly silicified; brachioles are splayed out on the slab surface from all five ambulacra (Plate 4, Figs. 29–30).

Ambulacra long and recurved, apparently reaching base of theca; using growth lines and internal calcite, base of theca (now eroded) apparently slightly convex and basals small to medium in size. Radials long with fine growth lines, ambulacra long, fairly narrow, with many side plate sets, brachioles still preserved attached to all five ambulacra, at least 18 mm long and about 0.2 mm wide, fairly well preserved, brachiolar plates 0.25 mm long and deep, food groove not seen except in cross sections where filled with pyrite specks. Back of slab ground down perpendicular to thecal axis to intersect summit (Text-



Text-Figure 25. Growth plots for five measured specimens (MCZ 1045–1047, 1049, and 1055) of *Cryptoblastus*? sp. A. Note that the pelvis hardly contributes to the length in side view (top center) and that BR shows no increase in size in these few specimens. Best-fit lines in all plots were hand fit.

Fig. 24F), deltoids apparently short, no evidence of deltoid spines, arrangement on summit apparently eight spiracles plus anispiracle. Number of hydrospires unknown. Specimen apparently about 8 mm long, based on distance from exposed base to start of summit in section, at least 7 mm wide.

Studied Specimen and Occurrence. MCZ 1040 from beds 150–175 ft (46–53 m) above the base of the Paine Member, Lodgepole Limestone, Northeast Baldy Mountain, southern Bridger Range, southwestern Montana.

Discussion. This specimen appears to be different from either of the other *Cryptoblastus*? species known from the middle or upper Lodgepole Limestone. It is similar to *Cryptoblastus*? sp. B in having a slightly convex base and occurring in the middle Lodgepole, but apparently does not have spiny deltoids. It differs from *Cryptoblastus*? sp. A from the upper Lodgepole in the shape of its base and in having larger basals. Better-preserved material will be necessary to completely identify this isolated specimen.

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